New Scientist

WEEKLY 4 December 2021

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Why we need to rethink our relationship with the wild

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Is our solar system weird?

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Virtual event

Why is laughter funny?

Despite being more like an animal call than human speech, laughter is an important form of communication. In this talk. neuroscientist Sophie Scott explores the history and neuroscience of laughter, explaining its role in socialising, play and the expression of emotion. Join us at 6pm GMT (1pm EDT) on 3 March 2022. Get your tickets online now.

newscientist.com/ ns-events

Online

Covid-19 daily update

Stay on top of all the most crucial developments in the pandemic with our free news round-up, updated every weekday at around 12pm GMT. There are also links to our exclusive features and interviews.

newscientist.com/ coronavirus-latest

Podcast

Weekly

This week, the team explains why the wet market in Wuhan, China, is back on top as the most likely place covid-19 originated. And if you want to improve your vision , forget carrots, all you need is some red light – well, maybe. The team digs into new research showing colour light can boost activity in cells in the eye. Plus: the odourless chemical we emit that seems to influence the behaviour of others; and why NASA has sent a spacecraft to smash into an asteroid.

newscientist.com/ nspod

BLICKWINKEL/ALAMY

Boss bird Waxbills with the reddest feathers become dominant

KATE LAXTON/UNIVERSITY COLLEGE LONDON

Volcanic oddity Tanzania's Ol Doinyo Lengai spews weird black lava

Video

The strangest volcano on Earth

Tanzania's Ol Doinyo Lengai volcano spits out bizarre black lava. Analysing it could help solve mysteries about our planet's mantle. But as our video shows, getting your hands on a sample isn't easy. Don't forget to subscribe to our channel for plenty more explainers and incredible discoveries.

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Newsletter

Wild Wild Life

Sign up now to get Penny Sarchet's delightful newsletter celebrating living things delivered free to your inbox each month. In the latest issue, she looks at what we can all do to help protect biodiversity and, among other things, what it takes to become the top waxbill in the tree.

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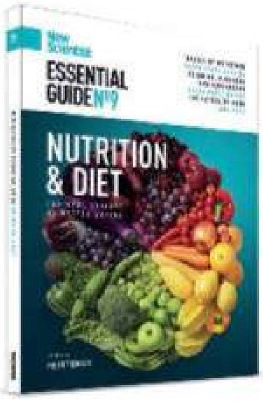
Newsletter

> **"There are things you can do that will make a difference to preserving the world's ecosystems"**



Essential guide

What is a healthy diet? There are few questions that throw up such conflicting advice. Our *Essential Guide: Nutrition & diet* delves into the underlying science for answers, covering everything you need to know about eating well and sustainably. Order your copy now.

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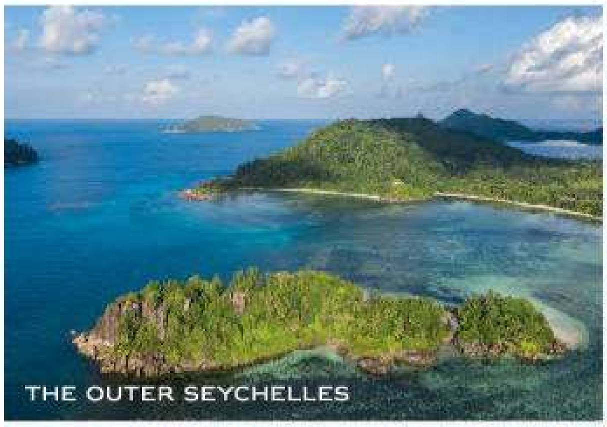

ON OUR WATCH

Hope can now be spotted across all our planet's seas and oceans. Sites are made into aquatic havens by local communities, to safeguard the richness and diversity of the ecosystems they depend on. Sylvia Earle's invaluable experience as an explorer and marine biologist continues to help further their goal, through her organisation, Mission Blue. Together, they have created over 130 Hope Spots and counting. Carrying a message of hope for generations to come. It is that vision, that dedication to a perpetual planet, which we are proud to stand by. **For as long as it is needed.**

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30% OF THE OCEANS BY 2030

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Welcome, science

Methane's climate impact was just one of the truths finally acknowledged at COP26

ONE of the positives to come out of last month's COP26 climate summit in Glasgow was official recognition of the central role that climate science must play both in understanding and solving the problem. That might seem an odd thing to say – surely science has always been at the heart of the negotiations? Sadly, it hasn't. At COP24 in Poland in 2018, for example, a report on the impacts of 1.5°C of global warming – specially commissioned from the Intergovernmental Panel on Climate Change (IPCC) for the meeting – was merely "noted" in the final text.

On that front, the newly agreed Glasgow Climate Pact is a major improvement. The final text explicitly acknowledges the latest IPCC report and notes its findings "with concern".

One area where the science really cut through was on methane – a powerful but short-lived greenhouse gas that has hitherto been treated as a secondary problem. Scientists have been arguing for a decade that cutting methane emissions is an obvious, simple and cheap way to significantly slow the rate of warming, but to little avail. As one leading researcher puts it, methane is a massive lever for effecting positive climate action, but nobody was seeing it.

> "Like London buses, you wait 25 COPs for action on methane, then two things arrive at once"

No longer. Like London buses, you wait 25 COPs for action on methane, then two breakthroughs come along at once: the Global Methane Pledge and a declaration from the US and China to collaborate on climate action. Together, these could shave a not-insignificant 0.2°C off warming by mid-century, using existing methane-busting technology and at no net cost. As we explain on page 18, this is great news, not something we are used to hearing when it comes to climate change.

But it isn't unequivocally good news. Grasping the methane lever doesn't buy us extra time to deal with the real villain of the piece, carbon dioxide. We still have to decarbonise immediately. And making pledges is no substitute for making changes. Despite the sudden swerve to methane, the Glasgow Climate Pact merely "invites" nations to "consider further actions" to reduce it. It has taken 26 COPs to put science where it truly belongs, but we still have some way to go. ▮

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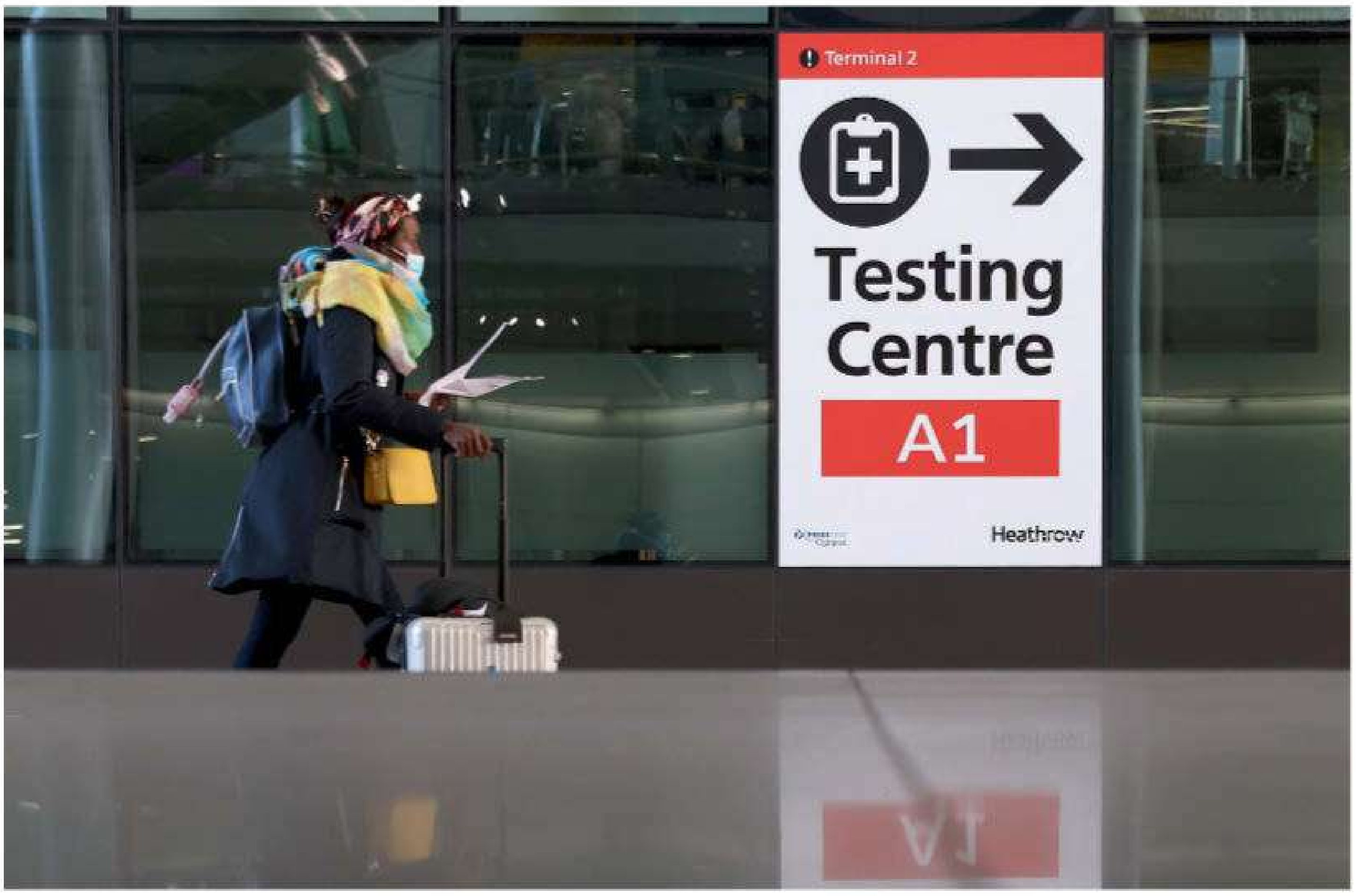

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A sign at London's Heathrow Airport on 28 November

Covid-19

Omicron emerges

The discovery of a highly mutated coronavirus variant in South Africa has triggered a global scramble, reports **Adam Vaughan**

THE omicron variant, which was designated a covid-19 variant of concern by the World Health Organization (WHO) on 26 November, has triggered travel restrictions, a race to accelerate booster vaccination programmes and renewed calls to address vaccine inequity.

According to the WHO on 29 November, omicron poses a "very high" risk globally, and preliminary evidence suggests that it might be a more transmissible variant, which could lead to surges of infection.

Countries including the UK, US and European Union member states have rushed to impose travel restrictions on southern African countries. Some went even further: Israel and Japan have effectively sealed their borders to foreign visitors.

South Africa's president Cyril Ramaphosa said he was "deeply disappointed" by the responses, and that the country was being punished rather than rewarded for its genomic surveillance.

Fears that the variant may undermine the efficacy of covid-19 vaccines have also led the UK and US to announce an acceleration of booster jab roll-outs, in the hope that more antibodies will provide better protection (see page 8).

The UK has also tightened rules around PCR tests for people entering the country, as well as bringing in self-isolation for contacts of suspected omicron cases and adding 10 southern African countries to the red list for travel. Mask-wearing has been reinstated in shops and on public transport in England.

New cases have been found around the world, from Australia and Canada to Hong Kong and Israel. The variant has been detected across Europe, including at least 13 cases in the Netherlands and 22 in the UK, as of 30 November.

Omicron was first identified on 23 November in South Africa by researchers using genome sequencing to investigate a puzzling surge in case numbers there. Daily cases went from 274 on 11 November to 1000 a fortnight later, and currently number more than 2000.

Researchers are concerned by the variant's high number of mutations. There are more than 30 of these in the spike protein, the part of the virus that interacts with human cells, enabling it to enter them, as well as mutations elsewhere in the genome. The virus's mutations could change how transmissible the virus is or the effect of treatments and vaccines, according to the UK Health Security Agency. But the body notes that "this has not been proven".

Such thinking about the potential impact of the virus's mutations is based on past SARS-CoV-2 mutations rather than lab tests. "It's important to stress how much we don't know about this new variant," says Sharon Peacock at the University of Cambridge.

Wendy Barclay at Imperial College London says "we don't really know" if omicron will reduce the effectiveness of vaccines. However, the number of changes on the variant's spike protein theoretically means that the effectiveness of antibodies produced by covid-19 vaccines would be reduced, she says.

Stéphane Bancel, chief executive of covid-19 vaccine-maker Moderna, has predicted that omicron will cut the efficacy of existing vaccines.

The new variant is also expected to be more resistant to antibody treatments such as those developed by Regeneron. "That is really a cause for concern," says Barclay.

Tedros Adhanom Ghebreyesus at the WHO said on 29 November that omicron's emergence shows that high-income countries must do more to donate vaccines to lower-income ones. "The longer vaccine inequity persists, the more opportunity this virus has to spread and evolve," he said. ▮

Vaccines

Booster shots prove very effective

Third doses are pushing covid-19 protection to impressive heights

Clare Wilson

THE outlook for the covid-19 pandemic took a downwards turn last week, when the omicron variant was announced as a variant of concern (see page 7). But there is a cause for some optimism: emerging evidence on vaccine booster programmes reveals that a third dose can take people's coronavirus protection to unexpectedly high levels.

It has long been predicted that the covid-19 vaccines from Oxford/AstraZeneca and Pfizer/BioNTech, which were designed as two-dose regimens, may eventually require a third shot. After studies suggested that vaccine effectiveness was waning, many countries began booster programmes, including the UK, which began offering third doses in September to people who are 50 or older and certain other groups. It later widened that to those aged 40 and over.

There was disappointment that boosters were needed after only six months, but the initial signs for how well third jabs are working have been no let-down. In October, a randomised trial found that people who had received a third dose of the Pfizer/BioNTech vaccine had about 95 per cent fewer infections than people who had only had two jabs.

While vaccine effectiveness tends to be lower in the wider world than in trials, real world figures have also been encouraging. In people over the age of 50, those who had a booster were about 93 per cent less likely to have a symptomatic infection than those who were unvaccinated, regardless of whether their first two jabs were AstraZeneca or Pfizer/BioNTech, according to an analysis by the UK Health Security Agency (UKHSA). "It's really impressive," says Paul Hunter at the University of East Anglia, UK.

The most recent results from the UKHSA suggest that, in the over 70s, for example, protection levels are now higher than they were in August, and seem to be continuing to rise.

People such as Anthony Fauci, the White House chief medical adviser, have said the covid-19 vaccines should be seen as requiring a three-dose regimen as standard. "A booster isn't an add-on – a booster is part of what the original regimen should be," he said at a conference in November.

Several other vaccines require three doses, such as the one against the liver infection hepatitis B. Giving sequential doses takes advantage of the fact that when we repeatedly encounter a pathogen or vaccine, our antibody-making cells undergo a process called "affinity maturation".

Our antibodies are made by immune cells called B-cells, and during affinity maturation, these multiply within the body's lymph nodes while undergoing mutations. Only the B-cells that make the best antibodies survive and replicate, so as a result, their progeny make ever-stronger antibodies. "With other infections, the third booster protects you for longer and also gives you antibodies that have higher affinity," says Hunter.

"With other infections, a third dose protects you for longer and gives you higher affinity antibodies"

This is good news for the many countries rolling out booster programmes. But information on the effectiveness of a third dose all relates to the delta variant, so how does the emergence of omicron change things?

Much about omicron is still unclear, but if it does replace delta as the dominant covid-19 variant, its genetic sequence suggests that the existing covid-19 vaccines may be less effective. That doesn't mean vaccines will become useless, though. "Vaccination is still likely to protect you from severe disease," Calum Semple, a member of the UK government's Scientific Advisory Group for Emergencies, told the BBC on 27 November.

That means encouraging as many people as possible to take the full three-dose course of vaccines is still a good plan of action for tackling any covid-19 variant, whether delta or omicron.

On 29 November, the UK's Joint Committee on Vaccination and Immunisation said that anyone 18 and over can have a booster, in order of descending age groups, and the required interval between second dose and third has shrunk from six months to three. The same day, the US Centers for Disease Control and Prevention said everyone aged 18 and older should get a booster too.

"If you're boosted, your response is likely to be stronger so it's more vital than ever that people get their jabs and we get those boosters into arms as fast as possible," said UK prime minister Boris Johnson on 27 November. ▮

MAUREEN MCLEAN/SHUTTERSTOCK

A road sign in Buckinghamshire, UK, in mid-November

Materials science

A better way to extract uranium from seawater

Matthew Sparkes

A MATERIAL inspired by the fractal-like nature of blood vessels can absorb 20 times more uranium from seawater than previous approaches. The team behind the technique believes it could provide a reliable energy source that could last thousands of years at current rates of consumption.

Uranium is the most common fuel for nuclear power stations, but it is a finite resource. Earth's seas are estimated to contain some 4.5 billion tonnes of uranium, 500 times as much as its land mass, but extracting it from water is more expensive than mining it from rock.

Experiments have previously found that sheets of acrylic fibre can extract small amounts of uranium from water, but because seawater contains only about 3 parts per billion of uranium, it has been difficult to refine the process and rival the cost of mining.

Linsen Yang at the Chinese Academy of Sciences in Beijing and his colleagues created a polymer membrane riddled with small channels that branch into even smaller tunnels just 300 to 500 nanometres across, mimicking the way that blood vessels bifurcate into ever-smaller passages within mammalian organs and limbs. The material was impregnated with a compound called amidoxime, which binds to uranium ions.

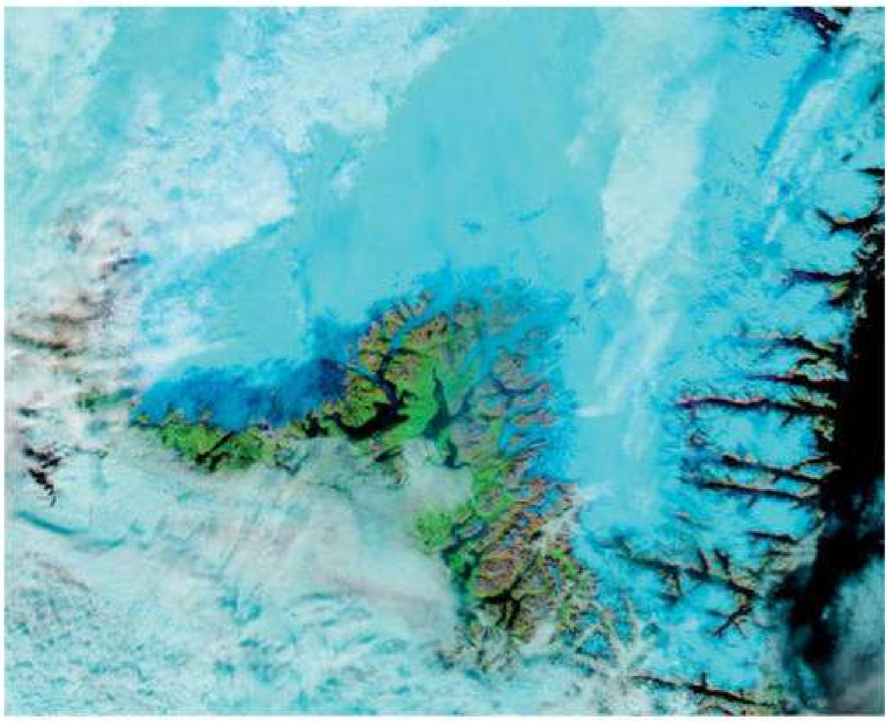
The team passed water laced with uranium through the material and found that it absorbed up to 20 times as much as previously developed materials did (*Nature Sustainability*, doi.org/g7m9).

Crucially, the uranium-laced membrane can also be cleaned with hydrochloric acid, which extracts 98 per cent of the uranium, and can be reused several times. This should allow it to be used for long periods of time and lower the cost of extraction from seawater even further. ▮

Climate change

Arctic precipitation may be mostly rain by 2060

Adam Vaughan



NASA EARTH OBSERVATORY

Satellite image of part of the Greenland ice sheet (light blue)

CLIMATE change could see the Arctic switch from being dominated by snow to rain up to two decades earlier than previously thought, with major consequences that risk accelerating global warming and devastating local wildlife.

Snow accounts for almost all current precipitation in the Arctic, but the region is warming faster than the rest of the world and is expected to become predominantly rainy this century. The transition has already begun: rain fell at Greenland's highest summit this year, for the first time on record.

Now, an international team has found that the switch from snowy to rainy conditions across the Arctic could happen in 2060 rather than 2080.

"It is all linked to the whole climate crisis, which is contributing to a much greater increase in rainfall," says team member Michelle McCrystall at the University of Manitoba, Canada.

Reindeer and caribou herders in the Arctic face a huge threat because rain falling on snow can cover vegetation in ice, leading to the mass starvation of the herbivores, she says.

The switch to a mostly rainy Arctic would have global impacts too. It is expected to accelerate the thawing of frozen ground, releasing the greenhouse gases locked within, and speed up the already rapid loss of Arctic sea ice. Such positive feedbacks would fuel even faster climate change, the driver of the transition from snow to rain.

1.5°C

may be enough global warming to turn parts of the Arctic rainy

"Generally speaking, if the warming will cause earlier onset of Arctic rainfall, that would obviously be bad for all kinds of reasons," says Richard Bintanja at the University of Groningen in the Netherlands. A 2017 study he co-wrote warned of "widespread, long-lasting and possibly even irreversible consequences" from the transition.

The impact of a rainier Arctic on Greenland may be a mixed picture, say McCrystall and her colleagues. While rain in summer and autumn will speed up melting at the edges of its ice sheet and drive sea level rise – a significant threat for coastal communities around the world – greater snowfall is predicted in parts of Greenland during winter, and this may offset some of the ice sheet's loss of mass.

The earlier switch to a rain-dominated Arctic emerged after the team ran a new generation of more-sophisticated climate models, known as CMIP6, projecting the future based on historical observations of precipitation, surface air temperatures and other data (*Nature Communications*, DOI: 10.1038/s41467-021-27031-y).

Qinghua Ding at the University of California, Santa Barbara, says the shift to an earlier rain regime is to be expected, as the CMIP6 models treat the climate as being more sensitive to the greenhouse gases we are pumping into the atmosphere.

One worrying finding of the new paper is that the switch to rain in many parts of the Arctic will now happen even if the world holds global warming to its goal of 1.5°C.

However, western European and Russian areas of the Arctic are still only projected to transition to rain if there is 2°C of warming.

"We can make changes [to the outcomes]," says McCrystall. "It's a call to action." ▮

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Mental health

US prisons put large numbers of Black men in solitary confinement

Alice Klein

ALMOST 1 in 10 Black men in the US are held in prolonged solitary confinement in prison at least once before their early 30s – a practice considered torture by the United Nations because of its severe impact on mental health. This is according to an analysis in Pennsylvania, where incarceration rates are representative of the whole US.

Solitary confinement involves isolating a prisoner in a cell – colloquially called "the hole" – for 22 or more hours a day with little to no human contact or mental stimulation. The UN's Nelson Mandela Rules state that it should only be imposed in exceptional circumstances and for short periods because more than 15 days of it constitutes torture.

Research shows the practice can induce anxiety, psychotic symptoms and post-traumatic stress disorder in prisoners. Those held in solitary confinement for any amount of time are 78 per cent more likely to die by suicide within a year of being released from prison and 127 per cent more likely to die of an opioid overdose in the first two weeks compared with other released prisoners who haven't experienced this type of confinement.

Hannah Pullen-Blasnik at Columbia University in New York and her colleagues analysed prison records from Pennsylvania spanning 2007 to 2018 to understand the use of solitary confinement. They found that 9 per cent of all Black men in Pennsylvania born between 1986 and 1989 had been held in such confinement for at least 15 consecutive days by the age of 32, compared with 3 per cent of Latino men and 1 per cent of white men (*Science Advances*, doi.org/g7kk).

These rates are probably nationally representative, since the incarceration rate and racial make-up of prisoners in Pennsylvania are close to the US average, says Pullen-Blasnik.

> **"Solitary confinement is almost never warranted because there are more humane options"**

Solitary confinement was used to punish violent acts in just 12 per cent of cases, according to the study. The rest of the time, it was used to punish verbal threats, possession of contraband or defiance, or because the prisoner was deemed a risk to others or unsafe themselves.

Tamara Walsh at the University of Queensland in Australia says that solitary confinement is almost never warranted because there are more humane and effective options available.

Prison violence can be cut by providing structured activities like athletics training, life skills training and playing board games, making sure inmates with mental health problems have appropriate treatment, allowing family visits and providing connections with nature, says Walsh.

New York and Colorado have banned solitary confinement being used for more than 15 consecutive days and are experimenting with alternatives. Colorado, for example, replaced long-term solitary confinement cells with short-term "time out" cells in some prisons and found that assaults declined by 40 per cent.

Pullen-Blasnik's research indicates that more Black men are placed in solitary confinement because more are incarcerated in the first place. "The most direct way to reduce solitary confinement among Black men is to shrink the [prison] system," she says. ▮

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Activists protest against solitary confinement in New York

Technology

Cryptocurrency traders are buying from themselves

Chris Stokel-Walker

THE majority of cryptocurrency trades on the world's most popular but unregulated exchanges may be people buying from themselves to artificially inflate prices, according to a new analysis.

A study of 29 cryptocurrency exchanges, where people buy and sell the virtual currencies, has found significant volumes of "wash trading" within cryptocurrencies. Wash trading is where an investor sells and buys the same asset to create artificial interest in an investment, often distorting the price.

Xi Li at Newcastle University, UK, and her colleagues looked at how bitcoin, Ethereum, Litecoin and Ripple – four of the most popular cryptocurrencies – were traded. They examined every trade made between the four cryptocurrencies and US dollars between July and November 2019, analysing them against statistical and behavioural benchmarks.

On the exchanges that are regulated, the researchers found little evidence of wash trading. However, they estimate that wash trading made up more than 70 per cent of the total volume of trades on unregulated exchanges during the study period (arxiv.org/abs/2108.10984).

Li says some crypto exchanges have changed their approach to wash trades since the study was done, but she believes the issue largely persists.

The paper's large data set and rigorous analysis make it an important insight into the crypto trading world, says Emiliano De Cristofaro at University College London. "Research studies year after year by serious scholars from multiple disciplines have pointed out how [cryptocurrency] trading largely involves fraudulent activities," he says. ▮

Cosmology

Mini black holes could spell trouble

Merging black holes may create bubbles capable of swallowing the entire universe

Leah Crane

LARGE colliding black holes could be a breeding ground for tiny black holes. If we spot signs of these cosmic lightweights, it could provide proof of the fundamental nature of our universe.

There have been hints in particle physics that our universe may not be in the lowest possible energy state – instead of a true vacuum, it may be in a state called a false or metastable vacuum. If any part of the universe were to collapse into a true vacuum, the laws of physics as we know them would collapse inside that bubble of vacuum, which would expand at the speed of light and eventually swallow up everything.

Some research has suggested that the extreme gravity near a black hole could create a foam of small bubbles of true vacuum. If those bubbles immediately fell into the black hole, though, that process could occur without destroying the universe.

Rostislav Konoplich at Manhattan College in New York and his colleagues calculated what might happen if these vacuum bubbles formed in between two colliding black holes. "In the region between the colliding horizons of the black holes, you have gravitational pull from both sides balancing out, so maybe for a short time interval the bubble can exist sandwiched between the two black holes," says Konoplich.

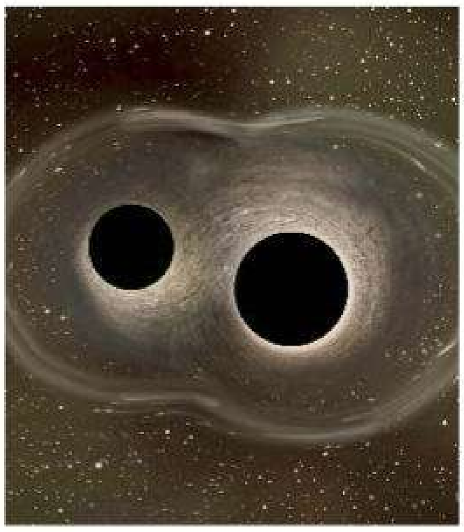
ESA

Illustration of two black holes spiralling towards each other

The surface of each vacuum bubble would be expected to form a kind of film similar to a regular soap bubble. Given even a small amount of time to percolate between a pair of black holes, the bubbles could be expected to collide with one another. The researchers calculated that if multiple bubbles collided at once, the intersecting surface could become infinitely dense, forming a micro- black hole (arxiv.org/abs/2111.07178).

Because of a process called Hawking radiation, these tiny black holes would emit a random mix of particles and evaporate away extremely quickly. Konoplich and his colleagues calculated that this entire process could take place in just about 10 milliseconds before the larger black holes collided and devoured any bubbles or micro black holes in their way.

But if bubbles of true vacuum do exist, it isn't necessarily a certainty that the bubbles will safely fall into the huge black holes that enable their formation, says Ruth Gregory at King's College London. "We know that these bubbles, once they're formed, start to expand quite quickly and rapidly reach the speed of light," says Gregory. "If they're outside the horizon, it might be that they would expand instead of falling in."

This would be a disaster of apocalyptic proportions. "If one of these bubbles of true vacuum escaped, it would destroy the universe – oops," says Gregory. The fact that the universe is still around suggests that bubbles of true vacuum are rare, if they exist at all, she says.

> "If one of these bubbles of true vacuum escaped, it would destroy the universe – oops"

However, if they do exist and form micro black holes, we could detect the random radiation from their eventual evaporation. "If we can detect something like this, it would be very important because it would prove that our universe is metastable from an observational result, not just theoretical," says Konoplich. That would be a major insight into the fundamental nature of our universe, which theoretical physicists are still debating. ▮

Plant genetics

Genetic diversity of heirloom tomatoes is surprisingly low

THE colours, sizes and shapes of the tomato varieties traditionally grown in Europe vary greatly, but it turns out this diversity is only skin deep. Apart from the few genes controlling these obvious characteristics, these tomatoes are virtually identical genetically.

"It's like a desert with some oases of variety," says Jose Blanca at Valencia Polytechnic University in Spain. "The tomatoes that you find in the supermarket nowadays, they have more diversity than the traditional [European] ones."

A handful of varieties of tomato were brought to Europe from the Americas around the 16th century, and were then grown mostly by poorer farmers in Spain and Italy.

Blanca's team partially sequenced the genomes of more than 1000 tomatoes developed in Europe – and now classed as heirloom varieties – alongside another 200 or so modern varieties. The researchers found significant diversity at just 300 sites in the genomes of the heirloom varieties.

GAP PHOTOS/VIRGINIA GREY

Heirloom tomatoes come in many shapes and sizes

"There are few diverse sites, but the ones that are diverse, they are very diverse," says Blanca.

This is because the European farmers selected for mutants that had an obvious effect, he says. But because all the varieties derive from just a few plants that arrived in Europe in the 16th century, they remain very similar otherwise (bioRxiv, doi.org/g7mb).

The modern varieties were far more genetically diverse, in line with previous research. The reason for this is that modern breeders crossed plants with wild varieties to reintroduce some of the variety lost during domestication.

Having lots of genetic diversity is really important, says Blanca. It provides the raw material for creating new varieties that can cope with evolving pests and diseases, and with a changing climate. ▮

Michael Le Page

AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

With a gift in your Will you can play a key role in providing the science that will protect the health of future generations.

Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work.

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Your Will can fund the rational response to health challenges that medical science provides.

> **"As scientists, our duty is to secure the future of research for the generations that follow."**
>
> Professor Fiona Watt, President of the Medical Research Foundation and Executive Chair of the Medical Research Council.

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that research forward, are the key to meeting those challenges for years to come.

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Changing lives tomorrow.
medicalresearchfoundation.org.uk

"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

I firmly believe that a gift in your Will to the Medical Research Foundation is an excellent investment and will have a lasting impact on science and on the future of human health in the UK.

Please consider this very special gift today.

NLemoine

Professor Nick Lemoine MD PhD FMedSci
Chair of the Medical Research Foundation

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Archaeology

Pendant is truly ancient

Mammoth ivory ornament covered in dots is 41,500 years old

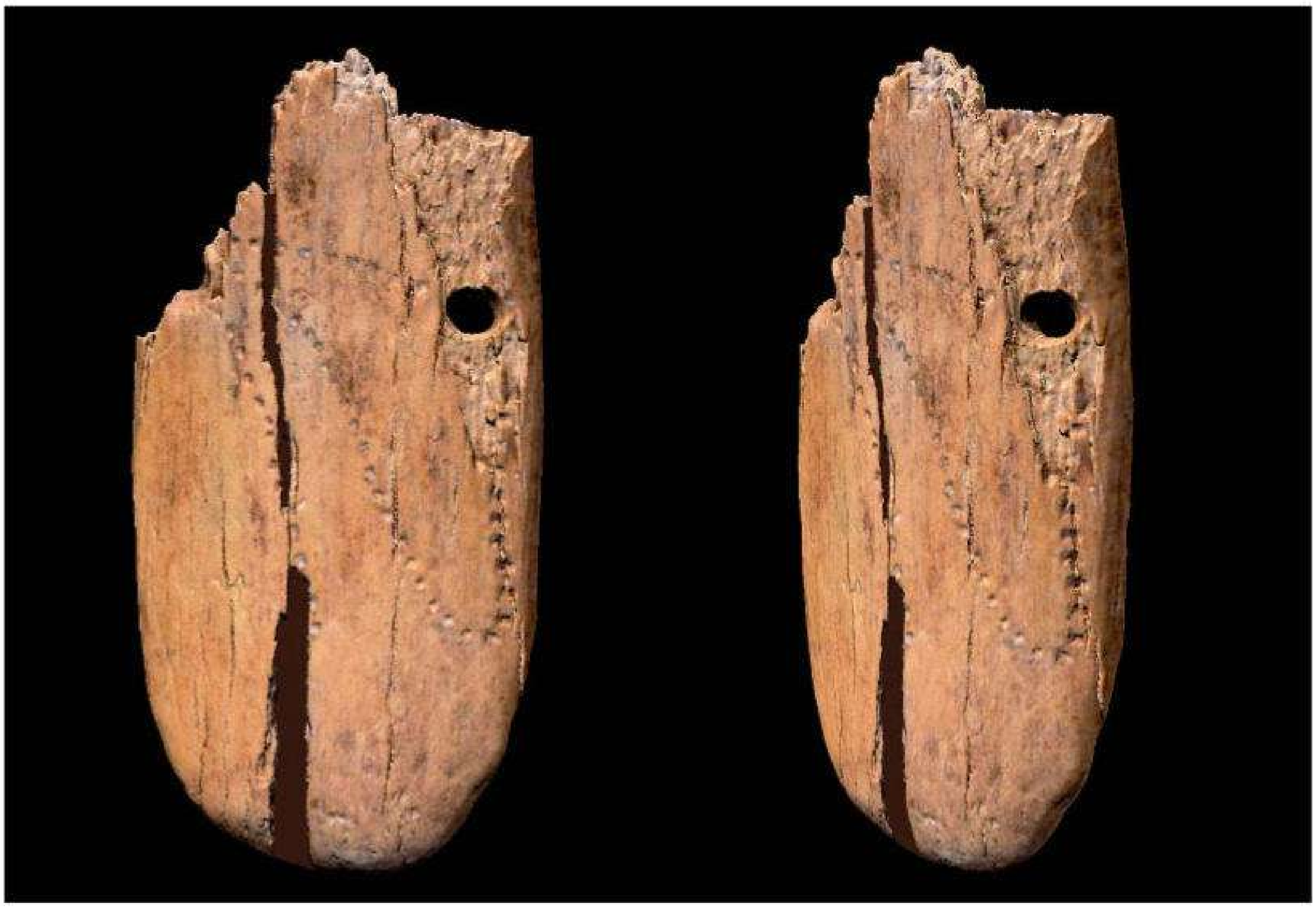
Alison George

A DECORATED piece of mammoth ivory is the oldest known example of ornate jewellery in Eurasia.

The oval-shaped pendant, 4.5 centimetres long and 1.5 cms wide, was unearthed in Stajnia cave in Poland. It has two holes drilled into it, presumably for threading, and is decorated with a sequence of more than 50 small indents in a looping curve.

"It's a beautiful piece of past work from *Homo sapiens*, an amazing piece of jewellery," says Sahra Talamo at the University of Bologna, Italy, who led the team that analysed the pendant (pictured from two angles).

Using a new radiocarbon-dating technique, the researchers discovered that the ornament was created 41,500 years ago, making it the oldest of its kind found in Eurasia (*Scientific Reports*, doi.org/g69s). "We were quite shocked," says Talamo.



ANTONINO VAZZANA - BONES LAB

Animal health

Feeding dogs once a day might help them age better

DOGS fed once a day are less likely to be diagnosed with age-related conditions than those fed more often, according to an analysis of surveys completed by 24,000 people with pet dogs.

For now, owners should stick with their current regime, says Matt Kaeberlein at the University of Washington in Seattle. "Based on this study, we are not recommending that people make a change in the way they are feeding their dogs."

In 2019, Kaeberlein helped establish the Dog Aging Project to study the genetic and environmental causes of ageing in these and other animals, including people. Any dog owner in the US can take part by filling in a survey once a year.

PLAINPICTURE/REALITYBITES

Fido may thrive on just a single bowl of fodder each day

There is some evidence that intermittent fasting can slow ageing in some animals, such as mice. Kaeberlein analysed the project data to see if dogs fed once a day were more or less likely to be diagnosed with various age-related conditions, from cancers to the canine equivalent of dementia, than those fed more often.

In most cases, dogs that were fed once per day were significantly less likely to have had such a diagnosis (bioRxiv, doi.org/g68w). "In my view, it's pretty compelling correlative evidence," says Kaeberlein.

However, the study hasn't established causation, he says. The total amount a dog eats, rather than how often it eats, might explain the correlation. Dogs fed twice a day or more might be more likely to be obese, for instance.

The advice currently given by many organisations is to feed dogs twice a day. If further studies confirm that once-a-day feeding is healthier regardless of how much dogs eat overall, it might lead to a change in advice, says Kaeberlein.

Feeding less often might be beneficial for dogs given their evolutionary history as hunters, says Kaeberlein – their wolf ancestors often went for days without eating.

Michael Le Page

Machine learning

AI finally learns to read the time on clocks with hands

Chris Stokel-Walker

READING the time on an analogue clock is surprisingly difficult for computers, but artificial intelligence can now do so accurately using a method that had previously proved tricky to deploy.

Computer vision has long been able to read the time from digital timepieces by simply looking at the numbers. But analogue clocks are much more challenging because of factors including variation in their design and the way shadows and reflections can obscure the hands.

Charig Yang and his colleagues at the University of Oxford have developed a system that can read an analogue clock, achieving 74 to 84 per cent accuracy when tested on 4472 images of clocks. They did so by training a computer vision model on computer-generated images of clocks seen from different angles (arxiv.org/abs/2111.09162).

These images, along with the correct time shown by the clocks, were used to train a spatial transformer network, which can warp an image taken at an angle in order to look at it face on.

This type of network has rarely worked when tested on photos of clocks from different angles before because it warps the images incorrectly, but the computer-generated data that was created here helped it to do this correctly.

The model was also trained on a set of time-lapse videos of clock faces, which improved its accuracy. When the model failed, it was usually because it confused minute and hour hands that were a similar length.

"It's an extremely creative application paper," says Arsha Nagrani at Google AI. While reading clocks might seem a fairly niche task, Nagrani believes the underlying concept can be used with any type of analogue machine, including other types of scientific instrument. ▮

Antibiotic resistance

NHS England to test antibiotic subscription service

Clare Wilson

A NETFLIX-style scheme to fund new antibiotics through a subscription – where a health service pays drug companies a set annual fee, regardless of how many doses are used – will start next year in England.

The approach tackles a key element of the antibiotic resistance crisis: that few new drugs are being developed, while existing ones are failing.

The field is currently unprofitable for pharmaceutical firms because when new antibiotics reach the clinic, health services use them sparingly, to slow the spread of bacterial resistance.

Under the new scheme, manufacturers Pfizer and Japanese firm Shionogi will receive fixed payments from England's National Health Service (NHS England) from April for two recently launched antibiotics, called Zavicefta and Fetcroja, respectively.

The amount to be paid hasn't yet been announced, but the UK government has previously said it could be as much as £10 million a year. "It doesn't matter if we use no pills, one pill or 10,000 pills," says Colin Garner at Antibiotic Research UK, a charity that wasn't involved in the scheme. "[Funding] is not at all related to the number of antibiotics used."

Bacterial resistance to antibiotics, used to treat conditions such as pneumonia, sepsis and wound infections, is seen as one of the biggest threats to public health. Resistant microbes have become more common as antibiotic use has increased, raising the prospect that simple infections will become untreatable, and common operations, cancer treatments and stays in intensive care units (ICUs) will be far riskier.

For years, various schemes have been debated to try to provide an incentive for companies to do research and development in this field. NHS England's subscription model is the first designed explicitly to reimburse firms with an amount that reflects an antibiotic's overall value to a health service, even if it is kept as a medicine of last resort and not used very much.

£10m

The amount the subscription service could cost per year

"If you have a patient in hospital with a resistant organism, it can totally disable an entire ICU," said Colm Leonard, a clinical advisor for the National Institute for Health and Care Excellence (NICE), speaking at a recent conference held by the UK Royal Society of Medicine.

NICE has recently completed an assessment of Zavicefta and Fetcroja for the purpose of the subscription model. Zavicefta is a combination of two drugs for treating conditions such as pneumonia and urinary tract infections. Fetcroja is aimed at infections caused by a hard-to-treat group of microbes called aerobic Gram-negative bacteria. The drugs are supposed to be prescribed only if the infection fails to respond to other antibiotics.

The US Senate is considering a similar plan to NHS England, set out in a bipartisan bill called the Pasteur Act, through which the US government would pay annual sums for new antibiotics based on their novelty and clinical value. "That would be a game changer," Sally Davies, former chief medical officer for England, said at the conference.

Sweden has also begun trialling a scheme that offers five antibiotic manufacturers minimum guaranteed payments for their drugs. This is designed to encourage firms to make existing antibiotics available in Sweden, because the country uses less antibiotics per head than similar high-income countries. ▮

A lab technician holds up a test plate for analysing antibiotics

DANIELA BECKMANN/SCIENCE PHOTO LIBRARY

Vision

Red light therapy could improve eyesight that has declined due to age

Clare Wilson

AN UNUSUAL experimental treatment for fading sight involves shining a weak red light into the eyes for a few minutes to boost the activity of mitochondria, microscopic structures that provide energy inside cells. In its first test, in 24 people, one short exposure to the light slightly improved people's performance in tests of colour vision for several days.

Deep red light and near-infrared light have previously been shown to enhance the function of mitochondria in a range of cell-based and animal experiments. These wavelengths seem to boost the performance of key molecular structures within mitochondria, called ATP synthase pumps.

The pumps make a molecule called ATP, which cells use for energy, by rotating within the watery environment of the mitochondria. Deep red light has just the right wavelength, at 670 nanometres, to be absorbed by water molecules, which gives them more energy. This makes the water surrounding each pump less viscous, letting the structure rotate faster. "It is like heating up jam to make it easier to stir," says Glen Jeffery at University College London.

Although making cells more energy efficient could affect a wide range of bodily systems, Jeffery's group has been investigating cells of the retina, a patch of light-sensitive tissue at the back of the eye, as they are packed with more mitochondria than any other cell in the body. Impaired mitochondria may contribute to declining eyesight with age and have been implicated in several causes of blindness.

A dose of red light treatment may help improve vision

SAC C WAT'HN BUY THNA THWI PHL/EYE EM/GETTY IMAGES

Previous work in flies suggested that mitochondria make most ATP in the mornings. So Jeffery's group carried out a trial of red light exposure in people aged 37 to 70, comparing treatment in the morning with that given in the afternoon, as a control group.

The participants had a weak deep red light shone at their eyes for 3 minutes. Three hours later, their colour vision was assessed with a letter detection test. The team focused on colour vision because the cells in the retina responsible for black-and-white vision tend to die with age.

When people received one treatment, between 8am and 9am, their performance on the test improved by 12 to 17 per cent, compared with before. Ten members of the group were also tested one week later and their results were still up to 10 per cent better. However, there was no significant change if the treatment was done in the afternoon (*Scientific Reports*, doi.org/g66n).

Louise Gow at UK charity the Royal National Institute of Blind People says the findings are exciting, but a bigger study is needed to see if the approach can noticeably improve people's vision. "A larger study would establish the evidence for this type of innovative treatment," she says.

Previously, other types of red light treatment have been found to benefit people with a common cause of blindness called age-related macular degeneration (AMD) and worsening eyesight caused by diabetes.

The treatment may help in a range of conditions because boosting mitochondria "turns on all the systems in the cell that make the cell work better", says Janis Eells at the University of Wisconsin-Milwaukee. Eells is working with a firm called LumiThera, which markets a red light device for treating AMD in some countries, although this uses a much brighter light and a wider range of wavelengths. ▮

Physics

Vapour cushions make levitating droplets antisocial

WHEN two different liquids are placed on a hot enough surface, they will levitate and bounce off one another, even when they would typically mix together easily, in what researchers have named the triple Leidenfrost effect.

The Leidenfrost effect occurs when droplets of a liquid skitter across a hot surface on cushions of steam instead of simply flowing together and remaining in one place. René Ledesma-Alonso at the University of the Americas near Puebla in Mexico and his colleagues found that these vapour cushions, called Leidenfrost layers, can also form between different liquids on hot surfaces.

"It was, like many new findings, a mistake in the lab," says Ledesma-Alonso. "Felipe [Pacheco-Vásquez, one of the researchers] was working with some students in the lab, and one of the students poured some ethanol in the same plate as the other student was pouring water."

The regular Leidenfrost effect happens because of the temperature of the surface being far hotter than the boiling temperature of the liquid, so the edges of the liquid boil and create Leidenfrost layers. When two liquid droplets on the same surface have different boiling points, the hotter liquid can also heat up the edge of the cooler liquid, creating an additional Leidenfrost layer that makes the droplets bounce off one another.

The researchers tested this with 11 different liquids, which they placed on a heated aluminium surface and filmed with a high-speed camera. When the liquids had different boiling points, they bounced off one another until the cooler droplet became too small to create a cushion of vapour. Then they merged (*Physical Review Letters*, doi.org/g66s).

"Bouncing lasted anywhere from seconds to a few minutes depending on the speed of evaporation"

The bouncing lasted anywhere from seconds to a few minutes, depending on the speed of evaporation of the cooler droplets. "There is a size limit, but not a time limit," says Ledesma-Alonso. ▮

Leah Crane

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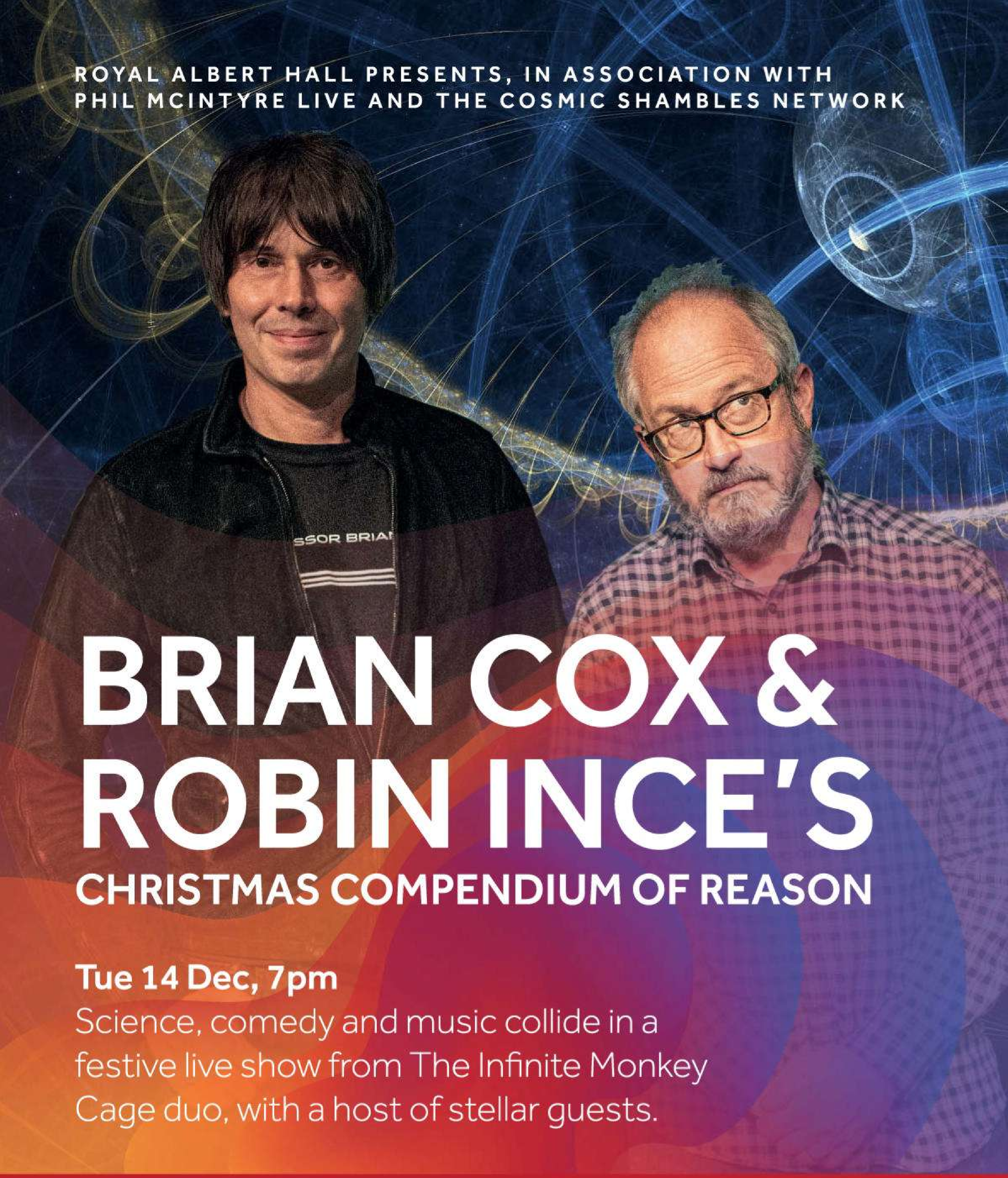

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WE'RE GOOD TO GO

Climate change

It's time to take methane seriously

Methane plays a big role in global warming and we already have the tools to curb its emission, reports **Graham Lawton**

AFTER a year of weather extremes, there can no longer be any doubt that the climate is warming rapidly, and no doubt that carbon dioxide is slowly cooking the planet. But the immediate culprit is a different gas altogether: methane.

A potent greenhouse gas, methane is largely responsible for the current rate of warming. It is thus a vital target in the fight to keep global temperature rises below the Paris Agreement's goal of 1.5°C – as well as offering some of the easiest wins. Yet it has been neglected. "Methane for so long has been a sort of Cinderella gas," says Euan Nisbet at Royal Holloway, University of London. With methane kept below stairs, its ugly sisters carbon dioxide and, to a lesser extent, nitrous oxide (N_2O) have got all the attention.

No longer. At the COP26 climate summit in Glasgow, UK, last month, methane finally arrived at the party and won over the assembled dignitaries. World leaders lined up to declare it the belle of the ball, and more than 100 nations signed a pledge to slash its emissions by 2030.

"Methane has gradually emerged from under CO_2's shadow and been recognised as a problem"

JO-ANNE MCARTHUR ON UNSPLASH

The biggest source of methane is agriculture, mainly from livestock

Depending on how you measure it – which is one of the problems with curbing it – 1 tonne of methane has between 28 and 120 times more warming power than 1 tonne of CO_2. However, it stays in the atmosphere relatively briefly – about 12 years – before mostly being converted to CO_2, which hangs around for at least a century.

Yet it is present in the atmosphere in tiny quantities – lower even than CO_2, which accounted for 412.5 molecules per million in 2020. Methane is measured in parts per billion, and its current concentration is about 1880 ppb, up from 722 in pre-industrial times.

Human-made methane comes from myriad sources that have historically been hard to measure accurately and so have been tough to mitigate. The biggest is agriculture, largely rice paddies and livestock farming, accounting for 40 per cent of emissions. The next biggest, at 35 per cent, is the fossil fuel industry: methane often leaks from oil and gas wells and coal mines. The third biggest source is our waste, mainly landfills and sewage.

Its low concentration and our lack of knowledge – coupled with the fact that, around the turn of the century, methane levels in the atmosphere stopped rising – made the gas seem like "a pretty small player" in climate change, says Drew Shindell at Duke University in North Carolina.

For these reasons, when the world first came together to tackle mounting concentrations of greenhouse gases in the atmosphere, methane was seen as a second-order problem.

The methane mistake

It was included in the basket of six greenhouse gases that the 1997 Kyoto Protocol pledged to reduce. But the protocol – the first worldwide attempt to solve global warming – was really all about CO_2. The other five were converted into "CO_2 equivalents": their strength as greenhouse gases was calculated relative to that of CO_2 over 100 years. This figure was named "global warming potential 100", or GWP100.

That turned out to be a mistake. Even though methane was assigned a GWP100 of 21 (later revised upwards to 28), this severely underestimated its heating power in the short term. Yes, over the course of a century, 1 tonne of methane warms the planet 28 times as much as a tonne of CO_2. But most of that warming happens in the few years after it is emitted. "It was well intentioned to make the problem tractable, but we inadvertently backed ourselves into a corner," says Steve Hamburg at the Environmental Defense Fund in the US.

Climate scientists recognised the error and recalculated GWP over 20 years. Methane was originally given a GWP20 of 56, though this has since been raised to 86 – in part to recognise that the breakdown of methane can create ozone, another potent yet short-lived greenhouse gas. But the damage was done. Policy-makers had been handed a hammer marked CO_2 and everything else looked like a nail. "Methane just got regarded as a funny sort of CO_2," says Nisbet.

Even GWP20 underestimates the damage done by methane in the very short term. If there were such a thing as GWP1, says Hamburg, methane's would be a colossal 120. "The challenge we have is that these figures are not wrong, they're just misleading for policy," he says.

Even so, in the years since the Kyoto Protocol, methane has gradually emerged from under CO_2's shadow and been recognised as a problem – and a potential, albeit partial, solution to the climate crisis – in its own right.

One reason for the change of heart is that, for reasons not yet fully understood, the plateau in methane concentrations was temporary and levels are now rapidly rising. In 2000 and 2001, the atmospheric concentration of methane actually fell, but for 18 of the next 19 years, it rose. Last year saw the largest annual increase since records began in 1984.

With this rise has come significant warming over and above that caused by CO_2. According to Shindell, if you also take ozone into account, the latest report from the Intergovernmental Panel on Climate Change makes it clear that methane is responsible for about half a degree of the 1.2°C of warming so far. "[Curbing] methane is the most important thing we can do for the near term. It's the only way we can slow down the damages that are mounting," says Shindell. Hamburg agrees. "Methane is driving the social disruption and the ecological disruption that people are most concerned about," he says.

Global pledge

The urgency of the methane problem has been common knowledge in climate science circles for about a decade, says Hamburg, but it has now diffused to the policy arena. In the past year, both the United Nations Environment Programme (UNEP) and the International Energy Agency (IEA) have issued major reports on it. UNEP concluded that deep cuts to human-caused methane emissions were not only possible, but would go a long way to achieving the Paris target.

Cinderella's true society debut came at COP26, where the presidents of the US and the European Commission formally launched the Global Methane Pledge. At the time of the announcement, more than 80 nations had signed up, agreeing to work collectively to cut global methane emissions by at least 30 per cent from 2020 levels by the end of this decade. And 30 per cent is a minimum. "I think we can probably go beyond that," said US President Joe Biden at the launch.

What does that mean in terms of global temperatures? A joint US-European Union statement on the pledge said that a 30 per cent reduction by 2030 would shave 0.2°C off global warming by 2050.

This saving might sound like small potatoes, but given that all the warming so far amounts to around 1.2°C, about a third of which comes from methane, it isn't to be sniffed at. And 0.2°C is scientifically credible, says Hamburg. That doesn't mean global temperatures will fall, but it does mean they will rise less quickly than they would have done with business-as-usual methane emissions.

If the pledge is met, the amount of methane-induced warming will be held steady at the current level of between 0.3°C and 0.4°C, says Hamburg. Unlike CO_2, methane breaks down quite quickly, so we don't have to reduce it to zero in order to put its warming effect on hold, he says.

The IEA also did a quick analysis of the pledge, concluding that its impact on warming by 2050 would be equivalent to immediately switching all of today's cars, trucks, ships and planes to zero-carbon energy. "That is huge," says Tim Gould at the IEA.

40%

Proportion of methane emissions that are due to agriculture

30%

Reduction in global methane emissions pledged by more than 100 countries at COP26

0.2°C

Estimated reduction in the amount of global warming by 2050 due to this pledge

Rice paddies are a major contributor to methane emissions

PETER ESSICK/GETTY IMAGES/AURORA OPEN

Not everyone was convinced. A rapid analysis by climate scientists at the University of Leeds and Imperial College London, both in the UK, found that cuts of around 50 per cent were probably needed to shave 0.2°C off warming.

Since these analyses, the methane agreement has got bigger. By the end of COP26, there were 109 signatories, collectively responsible for about half of global methane emissions.

There are also heavyweight refuseniks: China, India and Russia, the world's top three methane belchers, although China said it "intends to develop a comprehensive and ambitious National Action Plan on methane".

The pledge has also been criticised for being non-binding and for lacking concrete targets and ways for signatories to account for cuts.

Nonetheless, according to Mark Brownstein at the Environmental Defense Fund, the pact could be one of the most significant outcomes of COP26.

In part, that is because the pledge is achievable with existing know-how, and at little or no cost. "All the technology to dramatically reduce emissions is in place," says Hamburg. That mostly consists of stopping leaks from the fossil fuel industry, which the IEA reckons can cut global methane emissions by 25 per cent for free. "Methane is a valuable commodity," says Shindell. "Many of the controls pay for themselves."

People often describe this as low-hanging fruit, but Hamburg thinks that fails to capture how easy it is. "There's a lot of fruit lying on the ground."

Beyond fossil fuels, the rest can come from other existing ›

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technologies, such as capturing methane produced from landfills, periodically draining rice paddies and feeding cows supplements that suppress methane production. A recent research paper by Hamburg, Shindell and others estimates that if every available methane mitigation technology were thrown at the problem, mid-century warming would be reduced by 0.25°C.

Down the road, there are technologies in development, such as direct air capture of methane and methane-lowering treatments for cows, that could take cuts beyond 30 per cent. "We have to be realistic: 100 per cent reduction will probably not be possible," says Hamburg. "But a 50 per cent reduction should be no problem."

Two-pronged approach

The problem of measuring methane emissions has also been cracked, says Hamburg. "Methane was lagging. We knew less about where it was coming from and how to measure it. And now it's leading. You can measure it on the ground, you can do it with drones, aeroplanes, satellites." He is running a satellite project, MethaneSAT, that will monitor emissions from the oil and gas industry and could launch as early as October 2022.

Meanwhile, UNEP has set up the International Methane Emissions Observatory to collate and curate all available data on the gas. Soon, reckless methane leakers will have nowhere to hide. "Transparency is coming," says Gould.

The recognition of methane is not just a political breakthrough, but a scientific one too, says Hamburg. "It really represents a major transition to thinking about climate as a two-problem crisis," he says. "We have the issue of short-lived climate pollutants [principally methane] which really drive the rate of warming in the near term. And then we have CO_2, and to a lesser degree N_2O, driving the total amount of warming in the longer term. That framing allows us to much more effectively address the crisis. So I think this is a major step forward, where we have two suites of gases and two suites of mitigation solutions."

REUTERS/MIKE BLAKE

Methane is collected from a landfill in California and used to power homes

> **"All the technology to dramatically reduce methane emissions is in place"**

Joe Biden at the Global Methane Pledge event at COP26

REUTERS/KEVIN LAMARQUE

Shindell echoes that we need to think of methane and carbon dioxide as separate problems in need of separate solutions. "CO_2 takes a long time to respond, so our efforts to decarbonise, while vital for the sake of the long-term future of our planet, really provide very, very little in the way of avoiding climate damages in the near term," he says. "That makes [methane] a quite distinct player in this game alongside, not instead of, efforts to combat CO_2."

However, we mustn't see methane reduction as a way of buying time to carry on fiddling while the planet burns. We also have to cut CO_2 deeply, right now. "We need to deal with both of them," says Hamburg. Gould supports this. "You really have to tackle them in parallel," he says.

The path to 1.5°C

Scientists recognise that shaving 0.2°C or more off warming in the short term will still be hugely beneficial. For one thing, it smooths the path to 1.5°C, or wherever we end up once we reach net zero. "We can greatly reduce the rate of warming and have a glide path to wherever we land," says Hamburg. "If we don't do it, we end up with a higher rate of warming, and then go down. That's a much more damaging pathway."

It could also allow us to limbo dance under some potential tipping points – where things could suddenly get much worse – that lie just beyond warming rising upwards of 1.5°C. "If we want to really lower the likelihood of multiple tipping points, we really have to hold the line at 1.5°C of warming," says Tim Lenton at the University of Exeter, UK. "The fundamental point is that if we can rapidly decrease methane emissions, that could really make a difference."

This, however, is still a big if. The methane pledge, if it is enacted, can create a much-needed firebreak in the escalating climate crisis. But it may yet turn into a pumpkin. What really counts are legally binding commitments, and on methane, these are still as rare and fragile as a glass slipper. The Glasgow Climate Pact agreed at COP26 does mention methane, but only once and quite feebly: it "*Invites* Parties to consider further actions to reduce by 2030 non-carbon dioxide greenhouse gas emissions, including methane."

"I'm dismayed," says Nisbet. "This is a very weak way to respond to the urgency of acting on methane." ▮

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Can Britain become a space pioneer?

The UK government wants to place Britain in the first rank of the world's space industry. So how can the country make the transition from global to galactic?

"The UK aims to dominate the small satellite launch market in Europe"

ELEN11/ISTOCK PHOTO

Britain has bold ambitions in space. Earlier this year, the UK government set out plans to become a major player in the global space market with the publication of its National Space Strategy. Its vision : "We will build one of the most innovative and attractive space economies in the world, and the UK will grow as a space nation. We will protect and defend the UK's interests in space [and] inspire the next generation and sustain the UK's competitive edge in space science and technology."

That requires a secure environment. In April, the government launched the UK Space Command, a military body tasked with creating a secure and resilient space environment for government, military, and industrial activity.

And the government plans investment too. This upgrade of the UK's space capabilities includes a £5 billion investment over 10 years in military satellite communications, and £1.4 billion more in other space technologies. The strategy outlines the way the UK will operate in space – including the opening of seven spaceports – in a wide-ranging 10-point plan. Capturing the European market in commercial small satellite launch is top of the list. This involves launching a rocket into orbit in 2022 – an anticipated first for any European country – as an early step.

But this ambitious approach also raises questions. Does the UK have the necessary expertise, technology and industrial infrastructure to achieve such goals? How will it approach satellite navigation following the UK's Brexit-linked departure from Galileo, the European Union's global navigation satellite system? And how can the UK develop its spaceport capability in line with bold sustainability and climate goals?

These questions were the focus of a recent online New Scientist debate -- *Can Britain become a new space pioneer?* – sponsored by BAE Systems. The debate brought together a panel of leading thinkers and experts on space to discuss the future of the British space industry.

This industry comprises over 46,000 individuals and is growing at a healthy 4.7 per cent annually. But the global space industry is even growing faster, at 5.6 per cent, so the UK needs to accelerate to keep up. That said, the UK is already a world leader in many space-related technologies, including quantum communications, scientific payloads, satellites – and using them to track and tackle climate change – and cutting-edge navigation systems. The nation is valued internationally as a big exporter of high-end space technology.

This expertise will be crucial, particularly in the wake of Britain's exit from the Galileo programme. This departure has "actually expanded our horizons ", said Air Vice-

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The panellists for the *Can Britain become a space pioneer?* debate (clockwise from top left):

Rebecca Evernden
Director of the Space Directorate, BEIS

Emily Gravestock
Head of Applications Strategy at the UK Space Agency

Air Vice Marshall Paul Godfrey
Commander of the UK Space Command

Dave Short
Technology Director at BAE Systems

Marshal Paul Godfrey, Commander of the UK Space Command, and encouraged the UK to look at other technologies to replicate aspects of space-based position, navigation and timing technology. "From a defence perspective, the GPS signal is vulnerable to jamming and to spoofing, so we need look at more resilient ways of doing this. And there are some amazing technologies out there that might allow us to do some of this terrestrially."

The UK's upcoming smallsat launch capability will also boost the resilience of UK communications, said Dave Short, Technology Director at BAE Systems. "You can put some tremendous capability into those small packets, especially when it comes to sensors and aspects of communication. And you've got a greater resilience that comes from having multiple capabilities integrated with each other in low Earth orbit."

The ability to launch satellites, sometimes at short notice, will be a boon for defence, added Godfrey: "Space is becoming more recognised as an operational domain – and it is also becoming more congested and contested at the same time. From a military perspective, the ability to have some sort of reactive capability is really exciting."

Remaining at the forefront of space also means fostering a diverse, wide-ranging workforce . "Of course, we need mathematicians, scientists and engineers who can develop the technical aspects of our space assets, but we also need data scientists and computer scientists to analyse the data coming down from the spacecraft and develop new applications," said Emily Gravestock , Head of Applications Strategy at UK Space Agency. "On top of that, the UK space sector needs to grow our many brilliant SMEs into larger businesses that can really take world-leading positions."

Developing educational avenues and harnessing the rich diversity of the UK population is crucial, and Gravestock highlighted a variety of opportunities for young people to get involved. "We work with partners, both in industry and government, to supply internships and space industry placements. We've also got an annual competition that encourages young people aged 11 to 22 to get involved in space-sector entrepreneurship ."

Geography also matters, said Gravestock. "We've made the effort to come out from just the southeast to stretch right across the UK. That's given a fantastic range of views in the UK space sector, with particular strength in Scotland. And we have got brilliant diversity – and diversity of thought – coming through ."

With its National Space Strategy, the UK has set out clear ambitions to advance as a major player in the global space market through home-grown talent, pioneering science and technology, and savvy commercial and international collaborations. If Britain is to become a new space pioneer, we will know before this decade is out.

More at: baesystems.com/futurespace

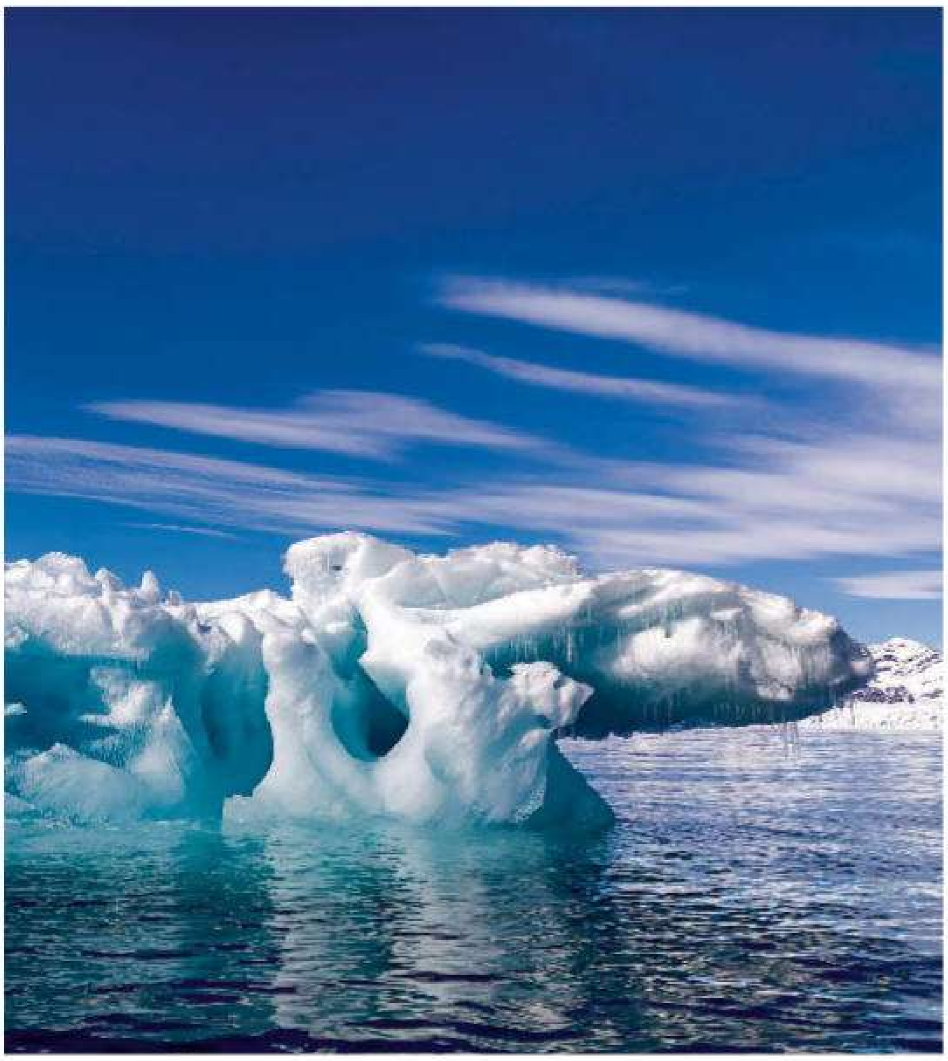
SUSTAINABLE SPACE

A key focus of the National Space Strategy is sustainability. It aims to support the UK's space sector "to integrate net zero thinking into its growth, monitor its environmental impact and encourage low-carbon and sustainable development". It will do this in part through the championing of bio-derived fuels. For example, launches from Space Hub Sutherland in Scotland by UK-based company Orbex will be powered by renewable biofuel rather than fossil-derived fuel.

Meanwhile, a rocket launch planned from the Saxa Vord Spaceport in the Shetland Islands by Edinburgh-based Skyrora will also fuelled by a more sustainable alternative to regular rocket fuel. Known as "ecosene ", this fuel is high-grade kerosene made from waste plastic such as polystyrene.

"Looking at technologies that offer more sustainable launches, looking at ways to reduce emissions and reduce impacts – particularly around the communities where those launches will be taking place – are all part of the package that the UK launch programme is looking for," said Rebecca Evernden , Director of the Space Directorate at the Department for Business, Energy & Industrial Strategy.

Dave Short from BAE Systems agrees. "The pressure of sustainability is irresistible. That's where the impetus for creative and innovative ways of developing those fuels comes from," he said. In addition, he noted that increasing capability can now be packed into small satellites. "The actual capability per pound is getting more attractive, and you're using less and less energy to get that capability into space. Having ever more compact solutions is another element of sustainability."



JANE RIX/ALAMY

Oceans

Warmer water may have got into Arctic over a century ago

SALTY Atlantic waters may have been seeping into the Arctic since the early 20th century, several decades earlier than previously believed. The Arctic is warming faster than any other part of the world and the increasing influence of water from the Atlantic Ocean, which is on average warmer and saltier than the Arctic Ocean, is likely to be leading to further ice loss.

Tesi Tommaso at the Italian National Research Council Institute of Polar Sciences says it is hard to quantify what is going on as we only have 20 years of confirmed data on the interaction of these waters.

To learn more, he and his team studied the Fram Strait in the Arctic Ocean between Greenland and the Norwegian archipelago Svalbard. They collected a 112-centimetre sediment core from the bottom of one of Svalbard's inlets in order to reconstruct the history of the strait.

The layers of the core correspond to sediments laid down over the past 800 years, which hold clues to the properties of the ocean at the time they were deposited.

The team found that for the earliest 700 years or so, nothing changed in the composition of organic matter in the sediment. But in samples corresponding to the year 1907, they saw a sudden shift in the oxygen isotopes in the organic matter (*Science Advances*, doi.org/g68m). "This change suggests the waters became a lot warmer and saltier," says Tommaso.

The researchers are unsure what caused this sudden shift. More data and modelling are needed to gain a clearer picture of what is behind it, they say. **Jason Arunn Murugesu**

Ancient humans

Baby Neanderthals got toothy sooner

NEANDERTHAL infants may have got their milk teeth earlier than us.

A new estimate of this comes from analysis of a milk front tooth in the upper jaw of a child who lived in what is now Krapina, Croatia, about 120,000 years ago. The tooth may have emerged sooner than we expect for our own species – from the age of 4 months rather than from about 7 months.

Front teeth are generally first to erupt, enabling infants to start eating harder food. Until now, little was known about milk tooth development in Neanderthals.

Alessia Nava at the University of Kent, UK, and her team used high-energy X-rays to take 3D pictures of the tooth. A tooth's crown is made of enamel. This is deposited by cells in a daily cycle, which gives it a pattern of stripes called cross-striations. The distance between adjacent stripes represents the amount of tooth growth in a day.

The researchers used these lines to assess how well-developed the incisor was at birth, and how much post-birth time was needed before it was mature enough to emerge. The group checked the estimate by analysing a jawbone from a Neanderthal that carries three teeth that were about to erupt at the time the individual died.

The team estimates that Neanderthals began to cut their milk teeth between around 4 months and nearly 8 months of age (*Proceedings of the Royal Society B*, doi.org/g68x). Modern human milk teeth typically emerge later, between around 7 and 10 months of age.

The researchers say that earlier tooth eruption may have enabled Neanderthal babies to eat harder foods at a younger age than modern human babies. This could have helped them meet the energy needs of their brains, which are thought to have been slightly larger than ours. **Carissa Wong**

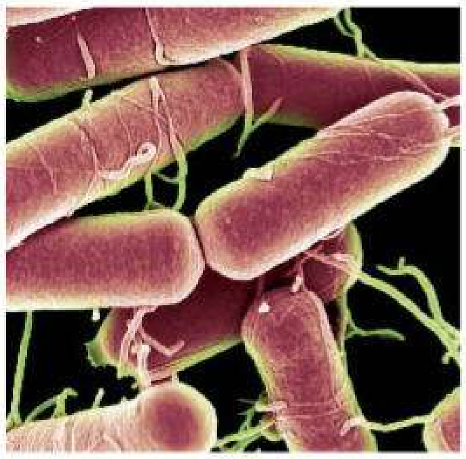
Health

Probiotic averts sepsis risk in mice

CONSUMING a bacterium found in soil helps mice avoid a blood infection that can lead to sepsis.

Sepsis results from bacteria, including *Enterococcus faecalis*. These can live in our gut without causing harm, but in people who take antibiotics for long periods or have treatments that weaken immunity, *E. faecalis* can get into the blood and cause sepsis.

Now, for the first time, there is evidence from experiments in mice that consuming a probiotic can prevent blood infection. The probiotic was in the form of spores from another bacterium, *Bacillus subtilis* (pictured). These are dormant forms of the bacterium that don't reproduce and resist environmental damage well. On entering the gut, they activate and grow, influencing the growth of other bacteria in the intestine.



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Michael Otto at the National Institute of Allergy and Infectious Diseases in Maryland and his team gave mice immunity-weakening treatment that people with blood cancer often have, followed by a cocktail of antibiotics.

The team then fed two doses of either *B. subtilis* spores or placebo before giving a dose of *E. faecalis*. The next day, the mice that had the placebo had *E. faecalis* in their blood, where it could cause sepsis, but those that were given the probiotic avoided blood infection (*Science Translational Medicine*, doi.org/gnksm9). **CW**

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Really brief

SHUTTERSTOCK/LUBOSLAV TILES

Trees help cities stay much cooler

In some regions of Europe, urban trees help keep surface temperatures 12°C cooler in summer, while other green spaces have a negligible effect. The conclusion comes from an analysis of data from 293 European cities. The effect is greatest in central Europe (*Nature Communications*, doi.org/g68n).

North America's unusual monsoon

A computer model suggests the monsoon that hits Mexico and the south-west US each summer is caused by the flow of air over the Sierra Madre Occidental mountains in Mexico. This makes it unusual, as monsoons are normally linked simply to the rapid warming of land in summer (*Nature*, doi.org/g68s).

Loss of megafauna led to more fires

Extinctions of giant bison and other large grazing herbivores in the past 50,000 years raised wildfire risks. On continents where the losses were most severe, there has been the largest increase in grassland fires, perhaps because the animals ate more of the potential fuel (*Science*, doi.org/g68t).

Bioengineering

Living ink can deliver drug or trap chemical

INK made using altered bacterial cells can be 3D printed into structures that release anticancer drugs or capture chemicals.

The microbial ink is the first printable gel to be made entirely from proteins produced by *E. coli* cells, without the addition of other polymers. By embedding another kind of genetically modified *E. coli* within the gel, Avinash Manjula-Basavanna at the Massachusetts Institute of Technology and his team built living structures that either released the anticancer drug azurin or captured the chemical bisphenol A (BPA), which has sparked health concerns.

The researchers made the ink from protein polymer molecules called curli nanofibres. First, they genetically engineered *E. coli* to create two types of cell. Both made subunits of curli nanofibres. One made fibres with positively charged units and the other negative. By growing a mix of the two types of cells, they produced curli fibres that cross-linked.

The team then filtered the bacteria to concentrate the crosslinked fibres, before removing the cells from the mixture. This produced a strong gel that had a suitable viscosity and elasticity for printing.

By altering more *E.coli* to make azurin when exposed to a chemical called IPTG, then seeding these cells into the gel, the researchers created a living structure that releases the drug on demand. They also made another form of *E. coli* to produce curli subunits that bind to BPA, again adding the cells to the gel (*Nature Communications*, doi.org/g68z). **CW**

Materials

SHUTTERSTOCK/BJOERN WYLEZICH

New type of diamond created by crushing buckyballs in lab

A NEW form of diamond has been made. Its unique structure gives it properties that are similar to those of natural diamonds, but it is more stable in extreme heat, so may be good in tools used in hot conditions.

There are two main types of molecular structure in diamonds and many other materials: crystalline structures, in which all of the atoms are neatly organised in repeating arrangements, and amorphous structures, which are mostly disorganised.

Howard Sheng at George Mason University in Fairfax, Virginia, and his team have made a diamond with a structure between these two forms for the first time.

The new material, called paracrystalline diamond, is made up of small structures called paracrystallites that consist of just a few carbon atoms. There is no particular order to the way the paracrystallites are arranged.

He and his colleagues created the material by crushing a type of carbon molecule called buckminsterfullerene, or buckyballs, between six ultra-hard carbide anvils. At pressures of around 30 gigapascals and temperatures in excess of 1200°C, the buckyballs turned into paracrystalline diamond (*Nature*, doi.org/g68p). **Leah Crane**

Chemistry

You just can't keep a good super gel down

A SOFT gel made of 80 per cent water has similar properties to shatterproof glass and can be run over by a car 16 times without lasting deformation. The material could be useful for soft robots, prosthetics and wearable devices.

Existing hydrated polymer networks, or hydrogels, are soft and stretchable, with rubber-like properties. But under high compression, they fail to bounce back to their original shape.

Now, Oren Scherman and his colleagues at the University of Cambridge have created a soft and compression-resistant gel that can rapidly return to its original shape, even after being repeatedly run over by a 1200-kilogram car.

The gel contains a polymer of two types of "guest" molecule – a perfluorophenyl and a phenyl – that sit inside barrel-shaped "host" molecules called cucurbiturils. The guest molecules are cross-linked to each other inside the hosts, forming a lattice network.

As the cross links form through attraction of opposite charges, they constantly unbind and reform, which could weaken the gel. The group modified the phenyl molecules to increase the time before this happens (*Nature Materials*, doi.org/g688). **CW**

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Culture columnist
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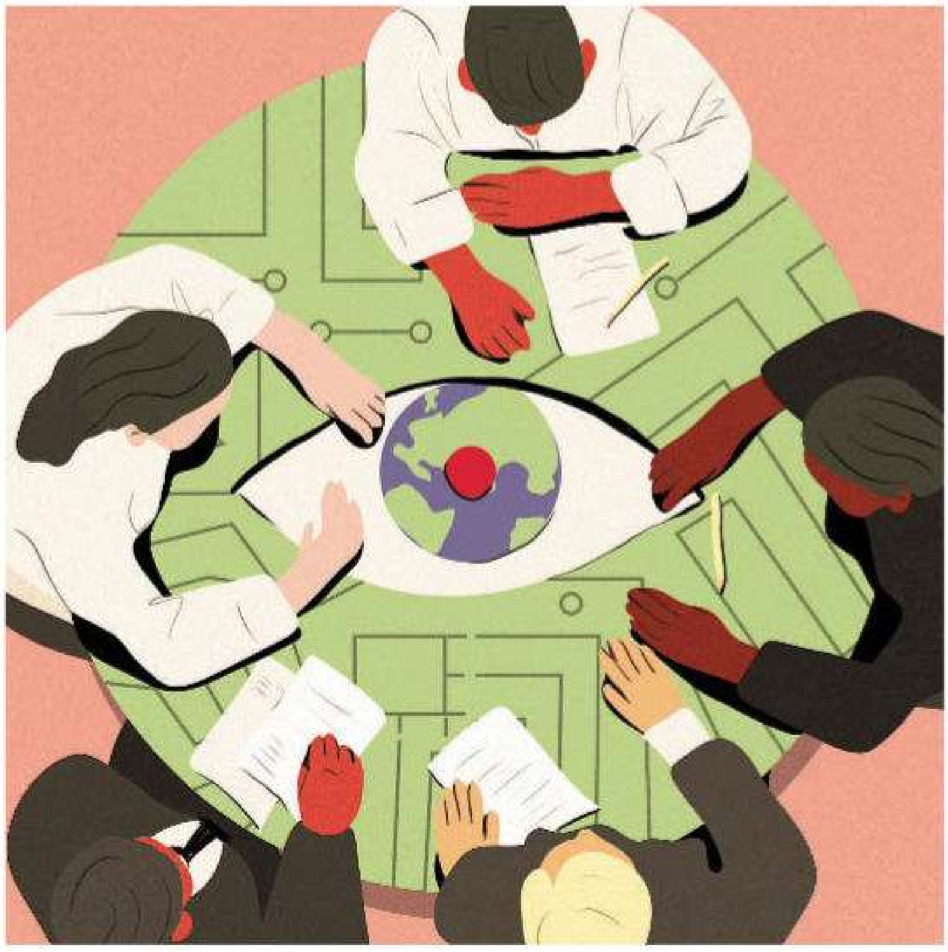
Comment

AI for all

Nearly 200 countries have signed UNESCO's agreement on AI ethics. This could help make the technology fairer for everyone, says **Gabriela Ramos**



MICHELLE D'URBANO

ARTIFICIAL intelligence is more present in our lives than ever: it predicts what we want to say in emails, helps us navigate and improves our weather reports. But the technology isn't always beneficial. The data sets used to build AI often aren't representative of the diversity of the population, so it can result in discriminatory practices or biases.

One example is face-recognition technology. This is used to access our mobile phones, bank accounts and apartment buildings, and is increasingly employed by police forces. But it can have problems accurately identifying women and Black people.

For three such programs released by major tech companies, the error rate was only 1 per cent for light-skinned men, but 19 per cent for dark-skinned men and up to a staggering 35 per cent for dark-skinned women. Biases in face-recognition technologies have led to wrongful arrests.

This is no surprise when you look at how AI is developed. Only 1 in 10 software developers worldwide are women and only 3 per cent of employees at the top 75 tech companies in the US identify as Black. But now there is hope that the world is about to pivot to a much better approach.

Last week at UNESCO, 193 countries reached a groundbreaking agreement on how AI should be designed and used by governments and tech companies. UNESCO's Recommendation on the Ethics of Artificial Intelligence took two years to put together and involved thousands of online consultations with people from a diverse range of social groups. It aims to fundamentally shift the balance of power between ordinary people and the businesses and governments developing AI.

Countries have agreed to implement this recommendation by enacting legislation to regulate the design and deployment of AI.

This means they must use affirmative action to make sure women and minority groups are fairly represented on AI design teams. Such action could take the form of quota systems that ensure these teams are diverse.

Another important principle countries have agreed to is banning mass surveillance and other invasive technologies that breach fundamental freedoms. Of course, we don't expect a complete withdrawal of CCTV everywhere, but we do expect such mass surveillance to be limited to uses that comply with human rights. UNESCO will use "peer pressure" to enforce global norms.

In the coming months, UNESCO experts will work to create a set of monitoring tools, ensuring that the development and deployment of AI complies with human rights, but doesn't stifle innovation. This will be a difficult balance to achieve and will require the full commitment of the scientific community.

The new agreement is broad and ambitious. It addresses online bullying and hate speech, and obliges countries to lower their carbon footprint from tech – the amount of energy used to store our data has risen significantly since AI innovation began to expand.

UNESCO now expects two things to happen. Firstly, governments and companies will voluntarily begin to make their AI systems comply with the principles laid out in the recommendation – similar moves happened after UNESCO's declaration on the human genome set out norms for genetic research. Secondly, governments will begin to legislate using the recommendation as a manual. Countries will be obliged to report on the progress of their legislation and UNESCO will monitor this.

With this agreement, we are confident of putting AI to work where it can have the most impact on the world's greatest challenges. We are optimistic we have built the momentum for real change. ■

Gabriela Ramos is UNESCO's assistant director-general of social and human sciences

#FactsMatter

Does plastic deserve its bad rap?

Campaigns to ditch plastic packaging on fresh produce might be well meaning, but the right wrapping can be better for the planet, writes **James Wong**

SOCIAL media can be a powerful force for positive change, especially when it comes to environmental issues. A seemingly perfect example is the drive to stem the tide of single-use plastic, particularly when it comes to food packaging.

Huge campaigns – including organised groups descending on supermarkets to strip and dump all packaging from their purchases and leaving it at the till in what is known as a "plastic attack" – have led to some quite dramatic changes, both in business and government. But it is possible that these sorts of well-intentioned moves, based on simple, social-media-friendly messages, can have unintended consequences.

The less geeky among us might overlook the fact that fruit and veg are still living plants, constantly interacting with the world around them in complex ways, some of which degrade the product. Under supermarket strip lights, they are still photosynthesising, making new compounds, breaking down others and even emitting growth regulators into the air that affect the behaviour of neighbouring crops on the shelves around them.

Understanding these incredibly sophisticated interactions and how to control them has spurred the creation of a branch of study called post-harvest technology. Over the past half century or so, this has led to a suite of ingenious inventions, including wrapping, that have dramatically extended the shelf life of crops. Waste has been slashed and nutritional quality and flavour improved.

Take, for example, a study published in 2011 showing that shrink-wrapped cucumbers lost a lot less water in a typical journey from farm to fork than the unwrapped equivalent, extending shelf life by up to 60 per cent.

Ditching this wrapping would therefore have a significant impact on food as, much of the time, the crop would go off before being eaten.

The upsides of plastic packaging don't stop with shelf life, but can retain the nutritional value of the crops too. Broccoli is a good example. It can lose up to 80 per cent of its glucosinolates, a group of phytochemicals thought to be responsible for some of the crop's key health benefits, when loose on supermarket shelves, versus the shrink-wrapped version in the chiller. Such effects have been found in a wide range of crops, which is one of the key reasons retailers go to the extra expense of using wrapping in the first place.

> "If food waste were a country, it would come third after China and the US in terms of carbon emissions"

It can be easy to assume that biodegradable food waste has nowhere near the same environmental impact as plastic waste that can persist for hundreds, if not thousands, of years. However, assessing this isn't that straightforward. While fruit and vegetable waste does break down fast into compounds, many benign, the environmental cost of producing these foods in the first place can be surprisingly high.

The United Nations Food and Agriculture Organization estimates that one-third of all food is wasted, and so many resources are dedicated to its production that, if food waste were a country, it would come third after China and the US in terms of carbon emissions. This is equivalent to 87 per cent of all road transport emissions. Based on such stats, growing this wasted food requires almost 13 per cent of the planet's farmland and, if all waste was averted, it would be enough to feed 2 billion people.

Admittedly, comparing measures like carbon emissions and land use with plastic pollution is getting into apples and oranges territory (excuse the pun), but given the importance of the issue, some research has tried to calculate the net effect.

A recent study published ahead of formal peer review, from the Swiss Federal Laboratories for Materials Science and Technology, looked at cucumber production and found that plastic packaging was responsible for only 1 per cent of the total environmental impact of this food, yet each cucumber that had to be thrown away because it spoiled has the net environmental impact of 93 plastic wraps. The study concluded that, in the context of reducing food waste, the plastic was beneficial: by extending shelf life, the net environmental benefit of wrapping cucumbers was 4.9 times higher than not bothering. This shows wrapping is a complex and confusing issue.

Given the clear benefits of using some plastic packaging on some crops, I wonder whether we should move away from the idea of blanket bans and instead review which types are genuinely of benefit for shelf life, and thus the planet, and which are simply there for marketing or presentation. And what about a third approach of swapping to alternative, more recyclable or perhaps even biodegradable packaging, for those instances where plastic does play a useful role, rather than ditching it altogether – even if such an approach doesn't get quite as many shares on social media. ▮

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, he shares his tiny London flat with more than 500 houseplants. You can follow him on Twitter and Instagram @botanygeek

James's week

What I'm reading

Stuck on the sofa for three weeks with an intense case of covid-19, I've been reading very little, sadly

What I'm watching

I have resorted to the film Shang Chi and the Legend of the 10 Rings. *The botanical errors are enough to infuriate even a mild-mannered plant scientist*

What I'm working on

Finishing up a new future-of-farming television series out next January on BBC World News

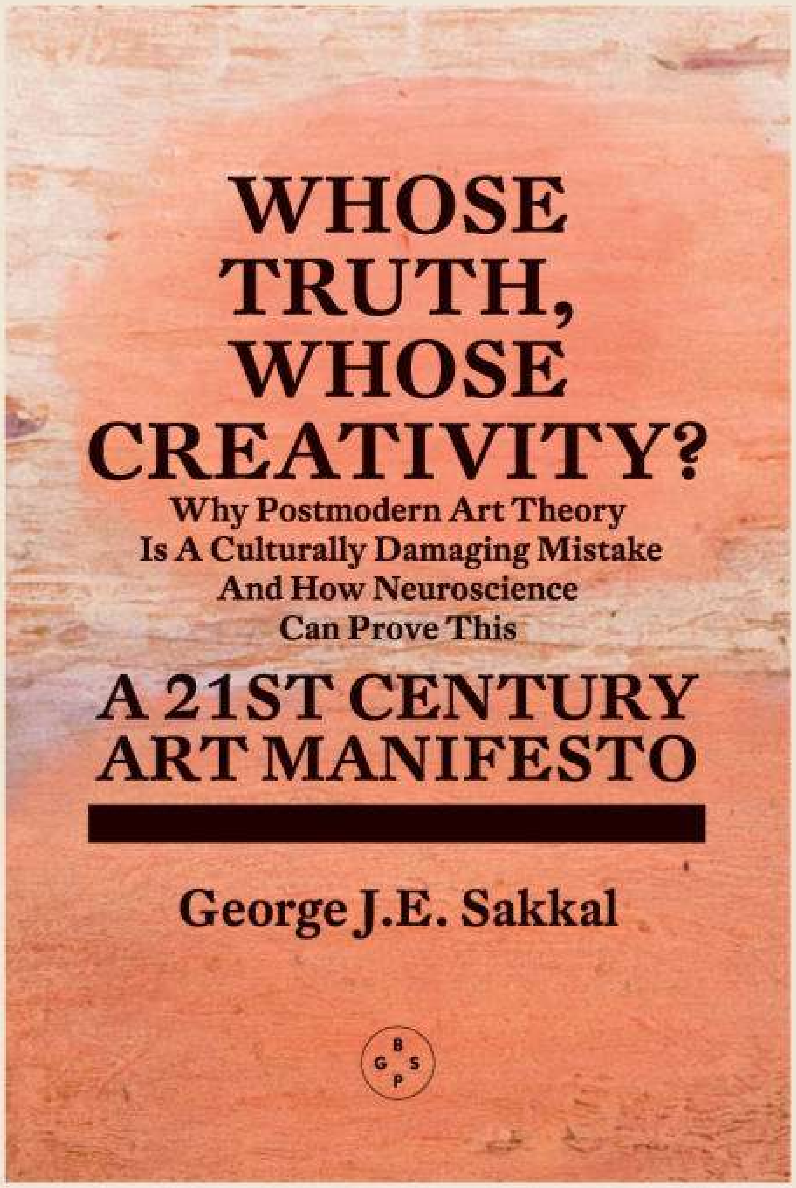
This column appears monthly. Up next week: Chanda Prescod-Weinstein

CAN ART THEORY BE SCIENTIFICALLY PROVEN?

Whose Truth, Whose Creativity? is an expert analysis of neuroscience and art theory — this new book delves into the source of all art and creativity, from ancient cave paintings to contemporary art. It explores why postmodern art theory has had a damaging impact on the art world and explains how neuroscience can prove this. Does talent spring from the unconscious mind as Paul Cézanne believed? Or does it, as Marcel Duchamp theorized, come from conceptual thinking at the conscious level?

Cognitive neuroscientific psychology, a fairly new field of psychology, explains a natural, mental basis for human creativity. This book exposes the many falsehoods and distortions of postmodern reasoning to demonstrate how, by following this disturbing, unnatural direction for decades, the art establishment has been responsible for initiating an era of damaging cultural chaos.

George J. E. Sakkal: For over fifty years, his avocation has been the practice of Fine Art. In addition to winning several national and regional competitions and exhibiting his work throughout the Baltimore / Washington D.C. region, he has lectured and taught collage and his discovery, CUVISM, at the University of Maryland's Community College in Columbia, Maryland. Sakkal has served as a Peace Corps Volunteer architect from 1966 to 1968 and an Associate Peace Corps Director from 1968 to 1971, both in Iran. He has a Bachelor's in Architecture from the School of Architecture at Texas A&M University and a Master's in City Planning from Harvard's Graduate School of Design.



WHOSE TRUTH, WHOSE CREATIVITY?
Why Postmodern Art Theory
Is A Culturally Damaging Mistake
And How Neuroscience
Can Prove This
A 21ST CENTURY
ART MANIFESTO
George J.E. Sakkal
B G S P

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His first article, *The Problem with Postmodern Art Theory*, was published by the *American Arts Quarterly Journal* in the summer of 2009. Examining the validity of the theories of contemporary art's Postmodern era resulted in his first book, *CUVISM (Cognitive Unconscious Visual Creativity): The Human Creative Response*, published in 2015.

VISIT THE AUTHOR / ARTIST AT **WWW.SAKKALCUVISM.COM**

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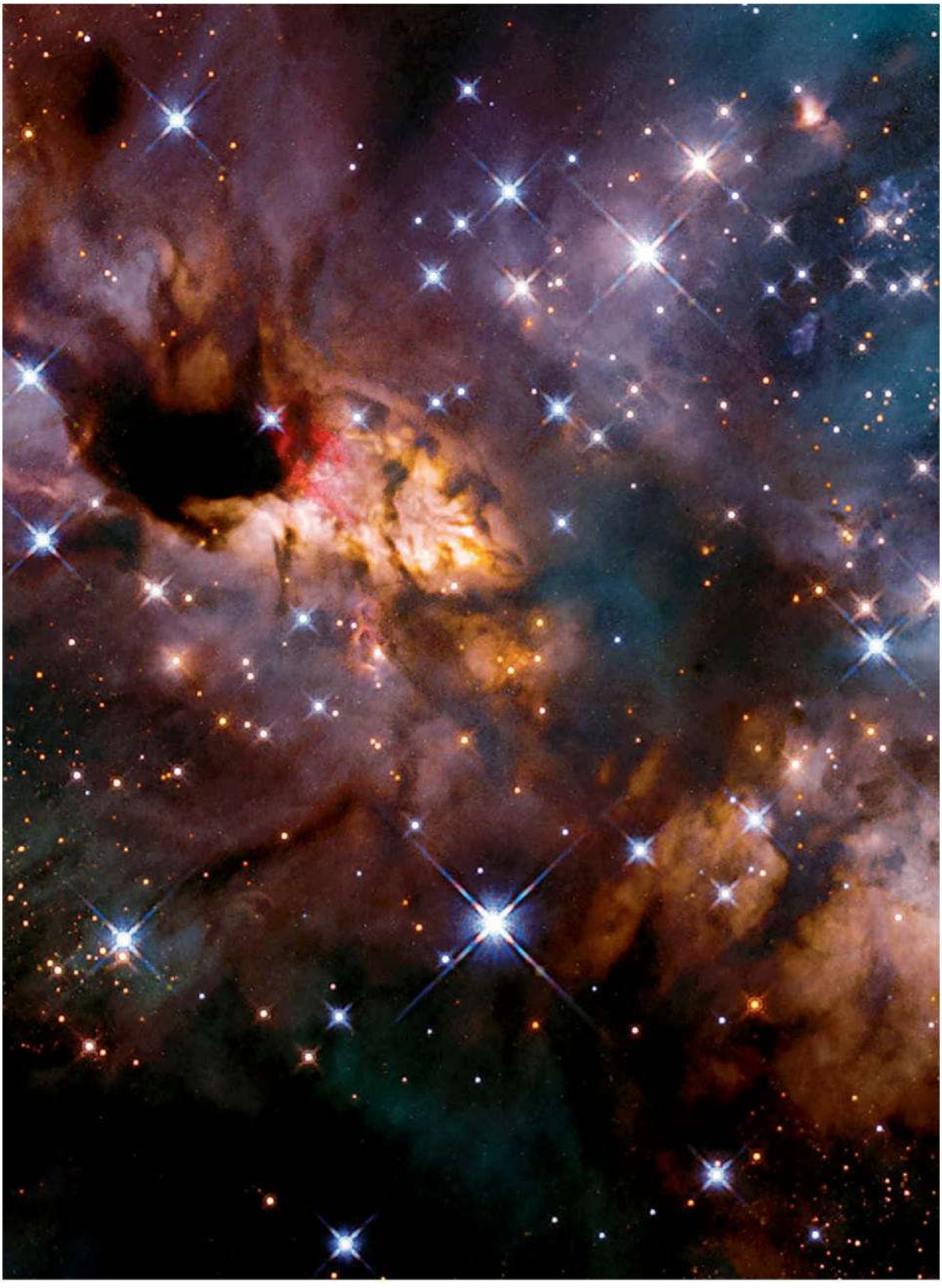

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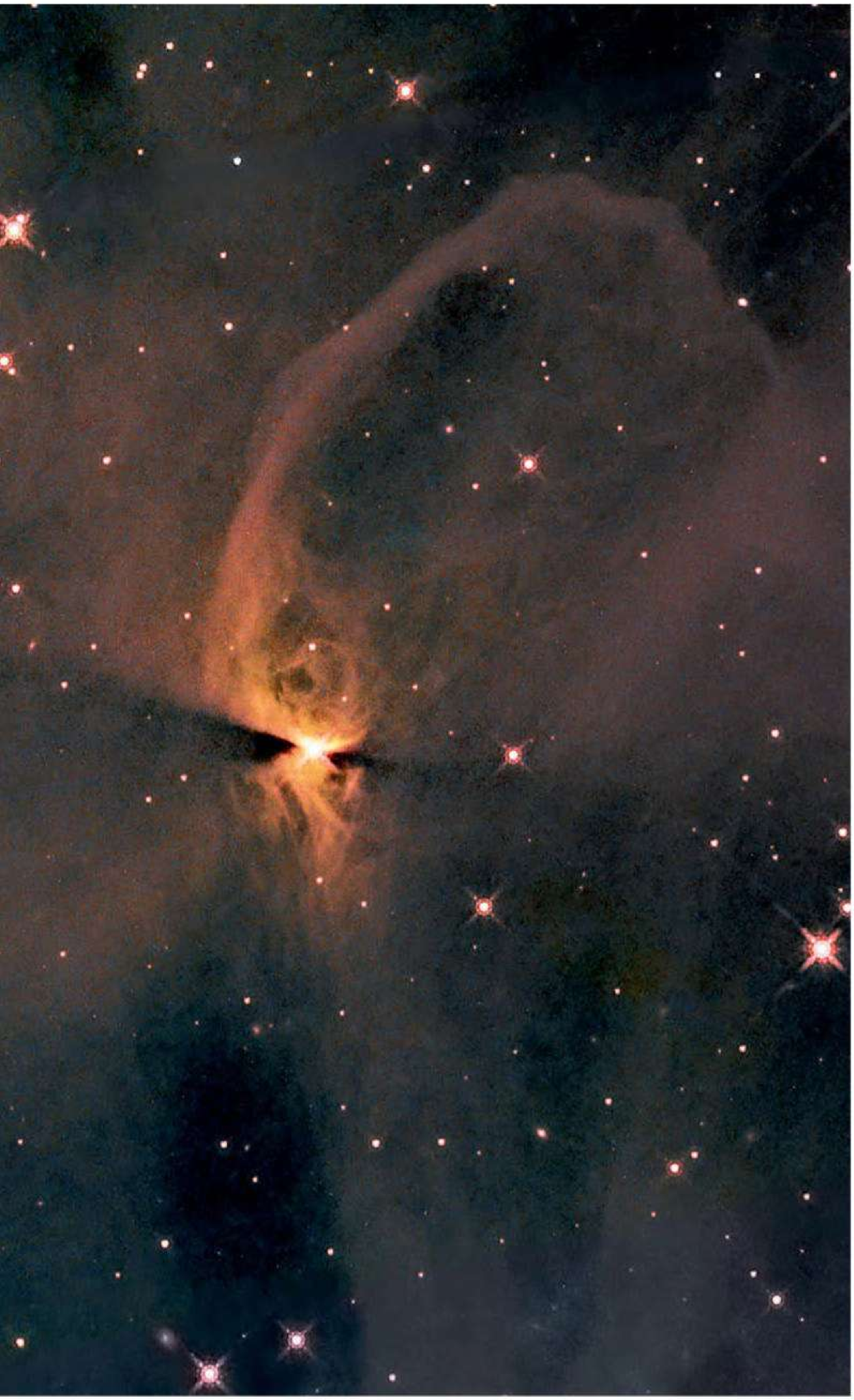

A star is born

Photograph **Hubble Space Telescope**

THESE two spectacular images are some of the most recent shots of our solar system snapped by the Hubble Space Telescope. Its goals include investigating celestial bodies, such as planets and stars, and probing how our universe is evolving.

The left-hand image shows the Prawn Nebula, a huge cloud of dust and gas often referred to as a stellar nursery because it acts as the birthplace for new stars. It is about 6000 light years from Earth and located in the Scorpius constellation, which is among the most prominent of the 88 constellations.

The Prawn Nebula is an emission nebula – its gases are ionised by radiation from its stars, causing the cloud to glow in both visible and infrared wavelengths. The area glowing red reveals ionised iron.

In the right-hand image, Hubble has captured the beginnings of a new star, known as a protostar, glowing yellow at the centre of the picture. These form when clouds of dust and gas collapse under their own gravitational attraction to form a hot, dense core, which in turn pulls in more dust and gas, making things even hotter. The heat of this process makes a protostar shine. This one, designated J1672835.29-763111.64, is part of the small Chamaeleon constellation.

Once enough material accumulates, this protostar's core will become hot and dense enough to spontaneously spark nuclear fusion, transforming it into a fully fledged star.

Gege Li

Editor's pick

COP26 summit was an opportunity squandered

20 November, p 9

From Bryn Glover,
Kirkby Malzeard, North Yorkshire, UK

As I read the accounts and reports from the COP26 climate summit, I got the impression that there was an attempt to find something positive to say. My reaction is that it was an opportunity squandered.

The event seemed badly planned and ineffectually and weakly led. I think it could have been substituted with a few well-placed Zoom calls.

Prior negotiations ought to have established tough goals out of which slick negotiators couldn't wriggle. It is clear that the major economies of the world are still placing their own domestic economic interests and their own leaders' electoral needs before the essential changes demanded by global humanity.

On the need for new minerals for renewables

13 November, p 38

From Will Kemp, Wagait Beach, Northern Territory, Australia

In your look at the impact of extra extraction of minerals required to expand renewable energy technologies, such as turbines and electric vehicles, environmental researcher Laura Sonter suggests that "social licence to operate" is important to the minerals industry.

Social licence to operate is a mirage conjured up by mining companies in an attempt to legitimise their operations. There are few, if any, examples of mines with explicit community permission to operate. The claimed social licence to operate is merely the absence of social injunction against operating.

From Anton Fletcher,
Droitwich, Worcestershire, UK

When considering the downsides of mining for minerals that are essential for electrification in pursuit of net zero, I expected to find some reference to the future use of hydrogen.

In the near future, we could have hydrogen-fired boilers in our houses and transport powered by modified engines using hydrogen, including jet engines. Where fossil fuels are now used, replace with hydrogen. If this were achieved, the need for mass electrification and associated mining disappears.

Quantum computers may not be a positive thing

20 November, p 7

From Eric Kvaalen,
Les Essarts-le-Roi, France

You quote Peter Leek at the University of Oxford as saying that the progress IBM has made with its 127-qubit quantum computer is "definitely positive" and "it's good that they're making something with more qubits".

I am not sure that it is good. It seems to me that we are in a quantum computing arms race, so we have to do this, but I don't think the world will be better or that we will be happier if we get quantum computers. For one thing, if they can factor large numbers, it will make encryption more difficult and will put past encrypted messages (that have been stored) at risk of being read.

Some evidence puts vegan substitutes in positive light

30 October, p 38

From Teri Lichtenstein,
Melbourne, Australia

The plant-based meat options in our supermarkets probably aren't marketed to be seen as healthier than the diet of nuts, vegetables and lentils that vegan pioneer Donald Watson enjoyed. But many are still preferable to the conventionally produced meat these products are designed to replace.

A report led by me and published in collaboration with Australian think tank Food Frontier shows plant-based meat tends to be lower in saturated fat and contains essential dietary fibre that animal products lack.

In addition, work by a team at Stanford University found that swapping animal-based meat for plant-based meat over an eight-week period led to weight loss and lowered cholesterol, while a study by Miguel Toribio-Mateas at London South Bank University and his colleagues concluded that replacing some meat with plant-based products promoted positive changes to the gut microbiome.

Does life have its own quantum reality rules?

6 November, p 38

From Peter Slessenger,
Reading, Berkshire, UK

Regarding the latest look at quantum theory's implications for reality. If the moon doesn't exist when you aren't looking at it, do I exist when you aren't reading my letter? More seriously, is being alive, even if no one on Earth knows, sufficient qualification for existing when no one can see you?

If so, what extra quantum-mechanical property does life confer on matter that makes it "real" irrespective of external observation?

From Iain Climie,
Whitchurch, Hampshire, UK

I would suggest that anyone querying whether things actually exist if you aren't looking at them has never stubbed a toe, reversed a car into an obstruction or suffered some other mishap or injury.

Less flippantly, given the severity of climate change and the inadequate attempts to mitigate it, why do people indulge in such navel-gazing? Anyone fancy telling those in low-income countries that droughts, heatwaves, poverty and locusts are figments of their imaginations?

From John Davenport,
London, UK

In "Is reality real ?", Thomas Lewton concludes that unless you hear the forest tree fall, it was never there in the first place. His conclusion is challenged in the same issue by the elephants in "Deciphering Dumbo" (p 42) that head for an unseen tree whose unheard fall they may have detected by its vibrations through their feet. They have no doubt that the tree exists, even when the vibrations cease, and Albert Einstein would have been delighted for them.

We must do more to protect Europe's forests

20 November, p 14

From Douglas Sheil,
Wageningen University & Research,
Wageningen, The Netherlands

I share concerns over increased tree mortality across Europe, but one assertion in your report on this needs to be revised.

Your story concludes by citing a much-debated claim that wood harvesting in Europe has risen by 50 per cent since 2016. Subsequent evaluations suggest a substantially smaller value of 6 per cent. The revised value results in part from a more careful attribution of tree loss due to droughts, storms and diseases, and includes all these additional processes leading to the increased tree deaths already noted in your story.

Everyone involved in these assessments agrees there are still uncertainties, but we are looking forward and seeking support for an urgent multidisciplinary and collective European effort to protect forests and better ensure their future resilience.

Want to get in touch?

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The best books of the year

Here is our pick of non-fiction books from 2021 to brighten those long winter nights. There's still time to add them to your wishlist, says **Simon Ings**

THE first rule of popular science is to reveal the wonder and mystery of the world. For that reason, *Sentient* (Picador), written by photographer and wildlife film-maker Jackie Higgins, is my personal pick of the year. It reveals how the 86 billion nerve cells in the human nervous system afford us not just five, but more than 30 distinct senses, all served by dedicated receptors. Here is a thought suitable for the season: did you know that mammals have a special touch receptor dedicated to cuddling?

Bodies and brains

Science writers found many more unexpected wonders to share with us this year. *Delicious* (Princeton University Press) raises the idea that our ancestors wiped out all manner of psychoactive treats as they worked their way through mammoths, mastodons, bison, Jefferson's ground sloths, giant camels and many more now-extinct species. The diet of the Clovis peoples of North America is a menu that husband-and-wife team Rob Dunn and Monica Sanchez describe as "a tally of a lost world". They go on to explain how we came by such a varied appetite and how our dinners robbed the world of so many large animals.

For inspiration on how modern humans can avoid doing the same, Jane Goodall's collaboration with publisher Douglas Abrams is a good place to start. In *The Book of Hope* (Viking), Abrams interviews Goodall, whose positive philosophy has been honed over a lifetime of commitment to the natural world. "It's mostly because people are so overwhelmed by the magnitude of our folly that they feel helpless," says Goodall. *The Book of Hope* is both a memoir of a well-lived life and a compendium of stories of "people who succeed because they won't give up".

New Scientist writer Graham Lawton spent a year keeping a diary of his "minor health woes". He ratcheted up more than 100, which he explores in detail in *Mustn't Grumble* (Headline). It's a romp through the science behind common ailments that ponders whether our day-to-day gripes are the best indicators of future health.

From healthy bodies to healthy minds. In *Move!* (Profile), Caroline Williams, another *New Scientist* regular, explores how moving our bodies can act as "a hotline to the brain", affecting the way we think and feel for the better.

Meanwhile, in Ginny Smith's *Overloaded* (Bloomsbury Sigma), we learn how the way we feel and even our sense of reality depend partly on how certain chemicals behave in our brains. As Smith explains, we often don't know how these substances work. But where there is clarity to be had, Smith brings it with aplomb, revealing the chemistry behind how we sleep, what we fear, who we love and even what we remember.

Not content with this wonderful chemical world, meddling with our brain chemistry, often by ingesting plants, is a favourite pastime of humans and other animals. Many evolved as a form of plant defence, including the sedative morphine, found in the opium poppy; the stimulant caffeine, found in tea and coffee; and the hallucinogen mescaline, found in certain varieties of cacti. In *This is Your Mind on Plants* (Allen Lane), Michael Pollan weaves tales of drug experimentation into a historical account of our long relationship with them.

Climate of change

In a tricky year for the climate, hope is something that Michael Mann has a surprising amount of. In 1999, he published a graph showing the rapid post-industrial rise in global temperatures. Two decades of harassment and death threats later, Mann remains convinced that we can prevent runaway climate change. *The New Climate War* (Scribe) sets out a common-sense approach to carbon pricing and a revision of the well-intentioned, but flawed, Green New Deal.

Of course, there are still many who deny that climate change is even happening. In *Saving Us* (Simon & Schuster), Katharine Hayhoe argues that this isn't necessarily a problem. A Canadian climate scientist living in Texas who is also an evangelical Christian, Hayhoe argues that since facts can be so easily manipulated and ignored, we should focus on our shared values, beliefs and enthusiasms instead. We may find we have more in common than we think.

'Tis the season to bury your head in a book filled with scientific wonders

> **"Our ancestors may have wiped out all manner of psychoactive treats as they killed off species"**

JELENA JOVIC/GETTY IMAGE

Inspiring memoirs

"I was always proud of my work," writes celebrated NASA mathematician Katherine Johnson in *My Remarkable Journey* (Amistad), "but for Pete's sake, I didn't do anything alone". Johnson, who came to public attention at age 91 with the publication of Margot Lee Shetterly's 2016 book *Hidden Figures,* focuses on those who encouraged and championed her career and helped her become a Black female pioneer in a field, and indeed a society, dominated by white men.

Physicist Kate Greene is another ground-based space trailblazer. She grew up wanting to be an astronaut and in 2013 she (almost) got her wish. *Once Upon a Time I Lived on Mars* (Icon Books) is her tale of spending four months in a geodesic dome in Hawaii, with five other people, to mimic living in a colony on another planet.

The experiment revealed many of the pitfalls future pioneers will face: "The same people, same seats at the table, same clothes, same smells, same routines, same view outside the one-and-only window looking out onto the same rocks. No sunshine on our skin, no fresh air in our lungs." Greene turns the longueurs and frustrations of her mission into a moving and compelling story.

Machines and minds

Meanwhile, on actual Mars, there is a spot that will be forever known as Larry's Lookout. It is named after Larry Crumpler, a geologist and part of the Mars Exploration Rover project, who reversed the Spirit rover up to this spot in 2005 to photograph the Gusev crater. His book *Missions to Mars* (William Collins), studded with full-colour photographs taken by rovers and NASA satellites, shows how robot technology has helped us see our planetary neighbour as never before.

Back on Earth, the robots are almost as smart. This, says Kate Darling in *The New Breed* (Allen Lane), means we should give some serious thought to our future relationships with them. Darling celebrates our ability to bond with those outside our own species (soldiers have mourned the loss of bomb disposal robots, and Darling mentions one trooper who sprinted under gunfire to rescue a fallen robot). But she reminds us that robots, unlike animals, are designed by people, and could be used to exploit our better nature.

A final note of caution about our technological future comes from Kate Crawford. In *Atlas of AI* (Yale University Press), she reveals the hidden costs of artificial intelligence, from the consumption of natural resources to the more subtle costs to our privacy, equality and freedom. ■

A year of great sci-fi

In a year with so many reasons to seek out escapism, we were spoiled for choice with sci-fi books.

Deep Wheel Orcadia (Picador) by Harry Josephine Giles was one of the best. It's a tale of a community of space miners faced with the possibility that the mysterious resources they have been extracting are actually sentient. Versed in Orkney dialect with an English translation, it is also perhaps the most unusual sci-fi offering of the year.

In the hyper-connected future of *Skyward Inn* (Solaris), humanity has spread to the stars, colonising inhabited planets as it goes. This is how a broad-chested, curly-haired extraterrestrial called Isley has ended up running a pub in England's west country, serving a native liquor that brings good memories to mind.

Isley is happy; so, by all accounts, is his planet. So why is there a mob gathering in neighbouring Simonscombe? What do they know that the rest of the world doesn't? In this book, Aliya Whiteley cements her reputation as one of our most exciting new novelists.

Kazuo Ishiguro's first novel since winning the Nobel prize in literature covers more familiar territory, with a recognisable yet slightly off-kilter version of our world. *Klara and the Sun* (Faber) tells the story of an intelligent, self-aware "artificial friend" who is navigating a dystopian world of human users who seem to have forgotten how to form attachments to each other and have lost sight of what really matters.

In an even more eerily familiar world, Calvin Kasulke's *Several People Are Typing* (Hachette) ponders whether corporate instant-messaging apps like Slack will ultimately suck your soul out of your still-living body. The result is a riotous techno-horror-comedy whose protagonist Gerald wakes one day to find his consciousness has been uploaded into his company's Slack channel. Will he escape? Will he want to? And will his bosses care either way? Since he started "working from home", there's been a leap in Gerald's productivity, after all...

More psychological insights are to be found in Adrian Tchaikovsky's *Shards of Earth* (Tor). In this universe, interstellar travel requires zipping through a dimension called "unspace", which, while convenient, wreaks a psychic toll that only a few, genetically enhanced humans can survive. On the plus side, it proves useful for those who need to bargain with planet-wrecking aliens.

Finally, Becky Chambers's *A Psalm for the Wild-Built* (Tor) is set on a moon called Panga, which is half protected wilderness, half industrial hellscape. Robots live in the wilderness and humans leave them alone. Then, Sibling Dex, a human "tea monk" (a kind of travelling therapist) heads into the wilds and makes contact with a robot, Mosscap.

It's the first time humans and robots have met in centuries and, amid all the dystopian science fiction on offer, their developing relationship offers a joyful interlude that brings a warm, fuzzy feeling that is perfect for the time of year.

The film column

Lights, camera, activism *Hawaiian Soul* is an uplifting short film that shows what can be achieved when people turn to passion and music to help protect what they love, says **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings

Film

Hawaiian Soul

‘Āina Paikai

Simon also recommends...

Film

Until the End of the World

Wim Wenders

An overlong but captivating science fiction film about a dream-recording machine that unexpectedly reconnects people to the land.

Book

The Swimmers

Marian Womack

Titan Books

Runaway climate change is a catastrophe for those born on Earth, but an opportunity for powerful forces in this coming-of-age tale, set in a brilliantly realised rural future.

COURTESY OF CCFF 2021/HAWAIIAN SOUL

The US military used Kaho’olawe as target practice for decades

WHAT IS the best way to carry out activism? How should we communicate bad news in ways that stir into action those who, not unreasonably, just want to get on with their lives?

Hawaiian Soul, a 20-minute short film directed by Hawaiian film-maker ʻĀina Paikai, asks those questions through the dramatised experiences of one man: the Hawaiian falsetto singer and musician George Jarrett Helm Jr.

Born in 1950, Helm was a guitarist and singer with a legendary vocal range. In his 20s he became a leading voice in Hawaii’s emerging Aloha ʻĀina movement, which translates as “love of the land” and spawned campaigns on environmental rights and Hawaiian sovereignty.

In 1976, Helm was part of a group called Protect Kaho’olawe ‘Ohana (PKO) which campaigned to stop the US military’s use of Kaho’olawe, the smallest island in the Hawaiian archipelago, as a firing range and for bombing target practice.

After an initial attempt to halt military activity failed, the group decided to land repeatedly and illegally on Kaho’olawe. In March 1977, Helm disappeared in high seas as he was attempting to reach the island on his surfboard.

In the film, Helm’s gentleness, charisma and regrettably short lifetime of activism – he was 26 when he vanished – comes to a head in a scene in which he and his fellow campaigners attempt to convince a sceptical and straight-laced church congregation to support the cause. While unilaterally unimpressed at first, Helm’s singing, and a stirring call to protect their shared homeland, ensures there isn’t a dry eye in the church. It is a moment that sounds like the purest schmaltz, but thanks to the film’s skilful editing, its talented lead actor and its use of archive music, the scene proves moving enough – and is entirely convincing, despite it being a work of fiction.

> **“Helm was a leading voice in the emerging Aloha ʻĀina movement, which translates as ‘love of the land’ ”**

There is plenty that is authentic about the film, however. Kolea Fukumitsu, the son of one of Helm’s fellow activists, plays the adult Helm in *Hawaiian Soul*. Fukumitsu’s son, Kamakani, plays him as a child. The actors playing the three PKO leaders are all from Helm’s home island of Moloka‘i, where the film was shot, and all have connections to the people they are portraying.

The film was awarded the inaugural Ocean Bottle Film Award at the Climate Crisis Film Festival, which ran alongside the COP26 UN climate change conference. It was the first film-making prize to highlight the perspectives of Indigenous and marginalised people on the climate crisis.

“The most vulnerable communities have the least to do with carbon emissions,” Susanna Basso, who organised the festival, explained in an interview with the Sierra Club. “The least we can do as a festival is to give over our platform... and pass the mic.”

This is a film about the challenges of making your voice heard. Helm’s clout came from his artistic and cultural authenticity, and we see that this came not from where he was born, but from his effort, study, commitment and, above all, his patience.

Helm didn’t live long enough to see Kaho’olawe get the protection he wanted – that didn’t come until 1994. But in the setting of COP26 – the point of which was to allow nation states to posture, bargain and reach compromise – his music and simple, sincere words were an inspiring refreshment. ▮

AFGHAN CRISIS APPEAL

MEDECINS SANS FRONTIERES
DOCTORS WITHOUT BORDERS

An MSF paediatrician examines a newborn baby in the neonatal ward of the MSF Khost maternity hospital, Afghanistan, 18 October 2021. Photograph © Oriane Zerah

MARIA FIX, MSF NURSE,
BOOST HOSPITAL, AFGHANISTAN

"At the moment, we are the only major hospital in the region that is functioning. There are around 1.5 million people living in Helmand province and the health system across the region has essentially collapsed.

Our hospital is super-congested and we're incredibly busy. We have 300 beds, but at times recently we've had between 330 and 350 patients. That means a lot of juggling and making do, with children sharing beds. It's not ideal, but otherwise we wouldn't be able to treat all the patients coming to us. Our paediatric department is overwhelmed. We're treating a lot of malnourished children and their number is increasing.

Even before the change of government, around half of the population relied for food support on aid organisations, but now a lot of that support has collapsed and many children are going hungry.

I don't think you ever get used to seeing malnourished children. Often they arrive dehydrated and in shock. We work to stabilise them in the emergency room before moving them to intensive care and then to the inpatient therapeutic feeding centre, where we feed them and slowly build up their strength.

It's very moving to see a child who has been so sick and malnourished recover and come back to life. But it's challenging at the same time, particularly when you know that, even if we stabilise them here and they recover, they're going to face the same problems – the same lack of food – as soon as we discharge them. But we do what we can and it's important that we do.

It's so important that MSF is here. When I was preparing to travel to Afghanistan at the end of August, people asked me why I was going there just as everybody else was leaving. When you're here, it does feel like Afghanistan has been abandoned – so many international organisations have left. But I'm so happy and proud that MSF has stayed. The people here are suffering and it's vital for us to be here, providing medical care to people who so desperately need it."

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Don’t stress about it

Stress can be dangerous for your mind and body, but with some smart hacks we can avoid its worst effects and even turn it into a positive force, says **Catherine de Lange**

MANY of us have felt more than a little stressed over the past couple of years. For me, exhibit A is my teeth. A recent trip to the dentist confirmed that months of pandemic-induced jaw-clenching, product of the usual deadline stress amplified by the demands of two young children, had left four of them broken.

Crumbling teeth are small fry. Last year, the American Psychological Association found that two-thirds of people in the US reported feeling more stressed in the pandemic, and predicted “a mental health crisis that could yield serious health and social consequences for years to come”. Increased risk of diabetes, depression and cardiovascular disease and more are all associated with high stress levels. It’s enough to make you feel stressed just thinking about it.

Perhaps we just need to think about stress differently, though. That, at least, is the startling conclusion of researchers studying the mind-body connection. There are natural benefits to being stressed, they say, and if we change our “stress mindset”, we might be able to turn things around and make stress a positive influence on our lives. Fortunately, there are some simple hacks that will allow us to do this, and they bring with them the promise of better physical health, clearer thinking, increased mental toughness and greater productivity.

There is no denying that too much stress can harm both body and mind. It has been linked to all six of the main causes of death in the West: cancer, heart disease, liver disease, accidents, lung disease and suicide. It can weaken the immune system, leaving us more prone to infection and reducing the effectiveness of vaccines, and can mess with our guts, triggering disease-inducing inflammation. It can hamper cognitive performance, reduce productivity and increase the risk of mental-health problems including depression, while compelling us to make unhealthy life choices such as smoking and eating foods we know we shouldn’t. Small wonder that the World Health Organization has described stress as the “epidemic of the twenty-first century”.

SERGIO MEMBRILLAS

The stress mindset

Stress didn’t always have such a bad rep. When Hungarian endocrinologist and pioneering stress researcher Hans Selye brought the word into the medical lexicon, he defined it simply as “the nonspecific response of the body to any demand”. And the immediate physiological effects of stress – increased heart rate, sweaty palms, a sudden surge of energy and even tummy trouble – exist for a reason. “The body’s stress response is designed to help us thrive and survive when we’re faced with threats or challenges to our existence and to our goals,” says Alia Crum at Stanford University’s Mind & Body Lab in California.

It all starts in the amygdala, the brain’s fear centre, which is primed to detect threats. If the amygdala deems something to be of concern, it flags it up via the hypothalamus, which triggers the “fight or flight” response. Adrenaline courses through the body and blood flow increases, boosting alertness and priming us to run. Another hormone, cortisol, releases stored glucose to give us more energy, and dampens down processes like digestion. Body and mind are primed to either confront a threat or run away from it.

That might have been useful with a sabre-toothed cat, but seems less so when you are confronting a deadline. Yet it has long been known that acute stress responses can also help get us through challenging or threatening everyday situations. They can make us more alert and more focused. Although we find it harder to retrieve specific memories when stressed, stress hormones help move things from short to long-term memory storage. They also tell the body to prepare for potential damage, building new cells and ramping up our immune system. On a purely psychological level, even longer-lasting stress associated with life events such as the loss of a loved one or a divorce – or a pandemic – can bring long-term positives, says Crum. “They lead to profound changes in people’s experience of the world, their appreciation for life, their resilience and toughness, and their sense of connection to others and to their values.”

The Jekyll-and-Hyde nature of stress lies at the heart of the new school of thought about how best to deal with it. “For many years, the spotlight has been on negative aspects of stress, including detrimental health effects, loss of productivity and depression,” says Petar Jerčić, a researcher at Jamzone, a tech company in the Netherlands. That means most of us are unaware that a positive side of stress even exists, and we develop what psychologists call a “debilitating mindset” about it.

Mindsets are core beliefs about the nature of something, and although they aren’t

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necessarily right or wrong, they tend to be oversimplifications, says Crum. There is plenty of research showing that our mindset can have a profound effect on many aspects of our lives. People who view ageing negatively, for example, tend to adopt fewer healthy behaviours, are less likely to visit the doctor, and age worse and die sooner. Students who view intelligence as something malleable that can be worked on, rather than being fixed and genetically determined, feel more motivated, get better test scores and enjoy learning more. Back in 2007, Crum showed that hotel workers who considered their job to give them a decent workout lost more weight and had healthier blood pressure than those who didn't think the same job was good exercise.

Crum's interest in our stress mindset came after a late night as a doctoral student at Yale University, under a mountain of stress over what to make the topic of her thesis. "It occurred to me that the true nature of stress is complex, and we're forming mindsets about it that are overly simplified," she says. "Even if those mindsets have some connection to the truth, they might be having a negative effect."

To test that, she assigned volunteers who worked in an office into one of two groups. One group watched short videos that told them how stress is bad, causing workplace mistakes and illness. The other group learned that stress improves workplace performance, immunity and well-being. Sure enough, those who came to believe that stress is beneficial experienced fewer of its negative effects.

When that research was published in 2013, others were already coming to similar conclusions. One 2011 study followed more than 28,000 people in the US over an eight-year period, showing that when people under a lot of stress believed it was good for them, they fared better than people with less stress who believed it was bad for them. Worst of all was having a lot of stress and believing that is bad: people in this group had a 43 per cent increased risk of premature death in the study period. Another study followed 7000 people in the UK over a period of 18 years, and showed that those who believed their stress was bad for them had a higher risk of heart disease than those who didn't, regardless of how much stress they reported.

Crum believes there are four basic ways our mindset can affect our stress response. The first is shifting our attention: rather than noticing all the unpleasant effects of stress, a positive mindset allows us to focus on possible opportunities instead. Second, while not necessarily reducing negative emotions – you are going to still feel sad, angry or upset when dealing with a difficult situation – a positive mindset means these can be accompanied by positive emotions such as feelings of hope, connection or resilience. "The 'stress is enhancing' mindset is really powerful in that it reduces unnecessary stress – the stress about stress – and it also amps up positive emotions, which are really important for motivation and physiology," says Crum.

The third effect is on behaviour. People who view stress as bad tend to behave in one of two ways: they either "freak out", akin to the fight response, or "check out", a bit like a flight response. Faced with the stress of this article deadline, for example, I might work myself up into a lather, feeling so hyped up and on edge that I am unable to focus on the job at hand, or I might wildly procrastinate in the hope that the source of my stress might go away. For some, this flight from reality can also take the form of substance abuse, says Crum.

Those who have a positive mindset, meanwhile, don't dodge the unpleasantness of stress, but can use it to get stuff done. Crum's doctoral research showed, for example, that such people are more open and receptive to negative feedback, and more willing to persist in times of struggle. In 2020, her team showed that this applied even to those training to become US Navy SEALs. Cadets with a positive stress mindset got further, completed obstacle courses faster and received better feedback from peers and trainers. Jacob Keech at the University of the Sunshine Coast in Queensland, Australia, has found similar things to be true of two groups of people who tend to experience high levels of stress: university students and police officers. Those with a stress-positive mindset focused more on problems and attempted to address them, and also experienced feelings of stress less adversely. "These tendencies in turn predict stress-related outcomes such as well-being and performance," he says.

> **"There is no magic to thinking our way out of stress"**

SERGIO MEMBRILLAS

The last way that mindset affects the stress response is via hormones. In preliminary studies, Crum and her colleagues have found that people who view stress as enhancing, rather than debilitating, have better regulation of cortisol and dehydroepiandrosterone sulphate, a hormone that helps with brain growth after stress.

Thinking our way out of stress might sound like wishful thinking, but there is no magic to it, says Crum. "Our minds, our brains are connected to every organ in our bodies," she says. "They're the hub that helps us communicate between the outside and the inside worlds, and so it really makes a whole lot of sense that how we're organising and thinking about something can change how we feel and respond."

Interest is now growing in how we might all harness our mindset to turn stress to our advantage. Jerčić and his colleagues at Jamzone have created Stressjam, an interactive virtual reality game that trains people's stress mindset using real-time feedback on changes to their heart rate and breathing – a good proxy for the action of stress hormones, which are much harder to measure in real time. The game has been trialled in various environments, including the workplace and clinical settings, with positive results, says Jerčić.

Reframing anxiety

Although it is interesting to measure the physiology, Crum thinks it is important to focus on behaviour, too – not least because the short-term activity of hormones and the like won't help you deal with longer-term stresses such as those induced by the covid-19 pandemic. Her team has designed an online toolkit (sparqtools.org/rethinkingstress) that begins by teaching people about the two sides of stress, as well as the general power of mindsets in influencing our health. After that, there are three steps to shifting from a negative to a positive stress mindset.

The first is identifying the source of your stress and how you respond to it – for me, deadlines, and procrastination. This helps by moving the reaction from the emotive, reflexive amygdala to the prefrontal cortex, which is involved in more deliberate thinking and planning. The second step is to realise that we generally get stressed about things because we care about them, which is actually a positive. I get stressed about deadlines, for example, because I care about doing a good job.

Finally, you need to turn the stress response to your advantage. After all, what happens in our bodies when we are stressed evolved to help us deal with the toughest of situations. The rush of energy and boost of alertness are things we strive for at other times, but they need to be focused on the task at hand rather than on ways to avoid it, say. Reframing anxiety as excitement, for example, has been shown to help people do better in tests, negotiations and public speaking.

Keech, too, has been working on a simple intervention to help people turn their perception of stress on its head. Earlier this year, he published findings from a study of university students who were asked to visualise ways that the stress in their lives might have positive consequences. After two weeks, not only did they have a more positive mindset, but those who reported feeling the most stressed at the outset had tangible improvements in psychological well-being, perceived distress, mood, proactive coping behaviour and academic performance.

He thinks this visualisation approach could be applicable more generally. "For example, have there been times where you have experienced stress and then grown from the experience? Have there been times where having some pressure has assisted you to focus and get on with the job?" he says. If so, consider whether there are positive consequences of any stress that you are currently experiencing.

None of this spells the end of stress, of course. "Trying to get rid of your stress is like emptying out an ocean with a bucket. It's just silly," says Crum. "If you care about things in life, there's going to be stress." What matters is to keep in focus why you are feeling that stress – the things you care about – and use it to channel that evolutionarily helpful natural stress response.

Nor does it mean that all external causes of stress are good and should be tolerated. "This doesn't mean you can just tell your employees they should work more because stress is good for them, or put up with an abusive partner," says Crum. Rather, by helping people better utilise stress, the approach can help provide the focus and the motivation to get us out of stressful situations.

Ultimately, whatever is causing your stress, the way you view can become a self-fulfilling prophesy, so it really is time to stop stressing about it. "The mindset you have can be a defining factor in making that more positive, less detrimental reality occur," says Crum. Given all the debilitating consequences feeling stressed can have, that can only be a good thing. I have a feeling my dentist will agree. ▮

Need a listening ear? UK Samaritans: 116123 (samaritans.org). Visit bit.ly/SuicideHelplines for hotlines and websites for other countries.

Catherine de Lange is head of features at *New Scientist*. This is an edited extract from her new book *Brain Power*, out in January 2022

The myth of the wild

Our misconception of nature is harming all life, including ourselves, says **Emma Marris**

CLOCKWISE L-R: SHUTTERSTOCK/BMPHOTOGRAPHER; PANTHER MEDIA GMBH/ALAMY; ADAM JONES/GETTY IMAGES; ADAM BURTON/ALAMY

Over millennia, humans have shaped landscapes including the Australian outback and English Lake District and influenced the evolution of wolves and California condors

WHAT is nature? We tend to think of it as something "out there", far away. We watch it on TV, we read about it in glossy magazines. We imagine somewhere distant, wild and free, a place with no people and no roads and no fences and no power lines, untouched by humanity's grubby hands, unchanging except for the turn of the seasons. This is our mistake. This dream of pristine wilderness haunts us. It also blinds us.

After many years thinking and writing about nature and wilderness, I have come to see these concepts as not just unscientific, but damaging. The notion of a pristine ecosystem is a myth. Over millennia, humans have stirred up the global pot and changed the entire planet so that all organisms alive today are influenced by us. And it goes the other way, too. We humans are deeply influenced by the plants and animals we evolved with; we are part of "nature".

Changing our ideas about nature isn't easy. It is hard for you and me; it is probably hardest for those who have spent their lives studying and protecting wilderness. But it is crucial that we do. "Wilderness" rhetoric has long been used to justify denying land rights to Indigenous people and to erase their long histories. What's more, thinking of nature and humans as incompatible makes it impossible to revive or discover ways of working with and within nature for the common good.

All species that regularly interact shape each other's evolution. Natural selection favours organisms that thrive in their environment, and the environment is as much the living species in a place as it is non-living factors like climate. So, like all animals on Earth, our species has been affecting other species for its entire run.

Admittedly, for much of our history, our line hasn't had a particularly outsized influence. But by the late Pleistocene, *Homo sapiens* had become the best hunters on Earth and a wave of extinctions of megafauna – animals over about 45 kilograms – followed them as humans migrated around the globe. Climate shifts may have also played a role in some of these extinctions, but it is likely that people were at least partially responsible for many of them. There were probably some secondary extinctions, too – certainly of parasite species, perhaps also species of dung beetle that relied on the not insignificant dung heaps left by some massive creatures. Similarly, scavengers were in trouble, with fewer giant carcasses to feast on. North America lost seven entire genera of vultures, and the California condor only survived by taking advantage of beached whales and other marine mammals.

Megafauna, like all creatures, influenced other species in their ecosystems, so in their absence their landscapes transformed. In North America, the demise of large grazing animals had an effect not unlike erecting a deer fence around the entire continent. It meant more plants and, in turn, more fuel for fire. In Australia, areas of the outback that are now nearly treeless were once a mosaic of woodland, shrubland and grassland. As giant relatives of kangaroos and wombats and huge flightless birds disappeared, plant matter built up and then burned, starting a cycle of wildfires in some places that favoured the tough, fire-adapted species now common across the arid parts of Australia. The effects of Pleistocene hunters in Africa and Eurasia are more contested, but that doesn't mean our influence was less profound.

Many large predators went extinct during this time, but others evolved to thrive in the new normal. Whereas the extinct "hyper carnivores" usually specialised in just one or a few prey species, today's apex predators – jaguars, mountain lions, wolves, grizzly bears – are scrappy opportunists able to scavenge, eat plants, switch prey and make other behavioural choices. That flexibility is no doubt serving them well now as they struggle to hang on in the 21st century.

Human ancestors didn't only shape other species by contributing to extinctions. They also evolved mutually beneficial relationships with some species that changed both parties. Centuries or even millennia of Indigenous management left certain plants needing to be tended by humans for their reproduction and survival. In other cases, people directed the evolution of food species by selective harvesting and by replanting seeds of individuals with desired characteristics. And people moved plants around intentionally: in North America, for example, they brought fan palms to the Sonoran desert for shade and fruit.

Many Indigenous peoples use fire to manage both the land and its animals. Fire can keep down dry fuels, reducing the chance of a destructive, out-of-control fire later in the season. Fires also stimulate new plant growth, which is the most nourishing to many herbivores. So the practice both feeds wild animals and attracts them to be hunted.

Indigenous land management would have influenced the animals that lived in and around these ecosystems. More directly, ›

"Like all animals, our species has been affecting other species for its entire run"

humans altered the evolutionary trajectory of some wild animals so thoroughly that they ceased to be wild. Indeed, it is possible that the reason there aren't more examples of ecological "mutualisms" between humans and wild animals is that, in such cases, we have become so intertwined that we call our "partners" something else: domesticates. In this framing, dogs, for example, are just the subset of wolves that have mutualistic relations with humans.

Today, even the wildest of wild animals aren't only influenced by all those millennia of human-caused changes, they are continuing to adapt to our ever-changing ways. Wild animals make their own choices about what to do every day – in that sense they are free. But their daily choices involve navigating a world that has been rearranged for human needs and desires. And we profoundly influence the evolution of their minds and bodies. Elephants are losing their tusks as poachers kill the big tuskers before they can reproduce. Animals we hunt and fish intensively are becoming smaller-bodied as they evolve to reproduce faster.

Natural urbanites

As for the "wild" animals in our cities and suburbs, they have thoroughly adapted to our world. Those that communicate by sound, including birds, frogs and toads, have shifted the pitch of their calls and songs to be heard above the noises of cities and traffic. White storks in Spain stopped migrating when they realised they could just catch introduced crayfish and eat trash at the dump. Crows in Japan put walnuts in front of cars idling at red traffic lights and retrieve their prize once the shells have been cracked open. In New Zealand, house sparrows have mastered automatic sliding doors, triggering the mechanisms to get into lunchrooms and cafés. They have even learned to incorporate cigarette butts into their nests as a form of pest control, since the nicotine repels parasitic mites. Rats, pigeons and other organisms have so fully adapted to humans that they now depend on us.

Climate change is altering the ranges, annual cycles and behaviour of untold numbers of species. Great tits in the UK are laying eggs two weeks earlier, tracking the changing schedules of the caterpillars their nestlings eat. The caterpillars, in turn, track the bloom time of trees. Some caterpillars in the US are even evolving to lay their eggs on new plants – "weeds" from across the sea. Such relationships between new and native species are knitting together novel ecosystems around the world.

10 per cent

Land area in the Americas being farmed when Christopher Columbus arrived

>50 per cent

Portion of Earth's land actively used by humans for our own ends

2 kilometres per year

Rate at which insects on the British mainland are spreading north because of global warming

>50 per cent

Proportion of plants and animals whose range has shifted due to climate change

Human leftovers mean that white storks in Spain no longer need to migrate

JAH/ALAMY

Some animals are moving towards the poles and upwards in elevation as the climate warms. In mainland Great Britain, a study of invertebrates, including bees, butterflies, grasshoppers and spiders, showed them moving north at an average rate of almost 2 kilometres a year. Over half of plant and animal species in temperate North America have seen their ranges contract at the hotter edge, expand at the cooler edge, or both.

Not all animals move, though, or move the way you might predict. Researchers are uncovering more ability to adapt in place than they expected, which is encouraging. Animals tend to evolve smaller bodies in hotter temperatures, perhaps because they are less prone to overheating with a larger surface-area-to-volume ratio. Scientists have caught a population of a South African bird, the mountain wagtail, shrinking by 0.035 grams per year as its habitat warms. The American lobster and Atlantic cod have also shrunk as the north-west Atlantic Ocean has warmed.

Climate change is increasing plant growth in some ecosystems, creating more food for animals, but drought is setting up starvation scenarios and triggering catastrophic wildfires in others. More than any other human influence on Earth, climate change is global in scope, affecting all life, all ecosystems.

Few people argue that any level of human influence disqualifies a place from being "nature". Such a purist stance would imply that "nature" ended when human-caused climate change began. For many, "nature" is a property that comes in degrees: one can speak of places as being more or less natural. But even in this sense, there is no real room in the concept for us to imagine relationships between humans and non-human species that aren't destructive, since human influence by definition decreases naturalness.

More troublingly, not all humans are seen as separate from "nature". The way people use the word "wilderness" in particular perpetuates the colonialist myth that Indigenous people had no agency and couldn't modify, manage or influence the landscapes around them. To this day, professional

GIDEON MENDEL/GETTY IMAGES

Controlled burning has created many landscapes that we consider natural

> **"The 'wilderness' rhetoric has long been used to deny land rights to Indigenous people"**

ecologists measure the "ecological integrity" of North American landscapes by comparing their current state with the "natural range of variability", which is typically defined as whatever it looked like in the 300 or 400 years just before Europeans showed up.

And yet, Indigenous land management was in many places creating those "natural" states: prescribed burns maintained prairies and grasslands; hunting determined populations of prey species; harvest and replanting shifted the ranges and abundances of some plant species; agriculture domesticated others. When Christopher Columbus arrived in the 15th century, a good 10 per cent of the land area of the Americas was being intensively farmed or used for settlements. However, where colonisers saw this management in action, they often failed to recognise it, because of its different forms and because of their preconceived notions about the native people.

Colonial power play

Dismissing Indigenous land management as minimal, or treating pre-colonisation ecosystem changes as "natural," is sometimes misperceived as a compliment to peoples who were able to husband their resources without depleting them. But the "virgin wilderness" narrative has been used around the world to deny Indigenous people rights to their lands. In Australia, British colonists took land that was being actively managed by Aboriginal peoples on the basis that it wasn't improved or cultivated, and thus was *terra nullius* – no one's land. "Wilderness" thus isn't just a romantic ideal; it is also a colonial power play.

Around the world, Indigenous people have been evicted from their homes, which were later rebranded as "wilderness" and set up as places for white people to use for recreation and relaxation. In California's Yosemite valley in 1851, a unit of the California State Militia expelled a band of Ahwahneechee people, killing 23 and setting their houses and acorn stores on fire, to make way for gold miners. In 1864, US president Abraham Lincoln made Yosemite valley into a park – an act considered by many to be the beginning of the national parks system. Four years later, naturalist John Muir came to California and fell in love with the landscape. He called Yosemite "pure wildness" and wrote that "no mark of man is visible upon it". What Muir didn't realise – or allow himself to understand – was that the landscape he loved so ardently was created by the "Indians" he sneered at in his writings as unkempt blights on the landscape.

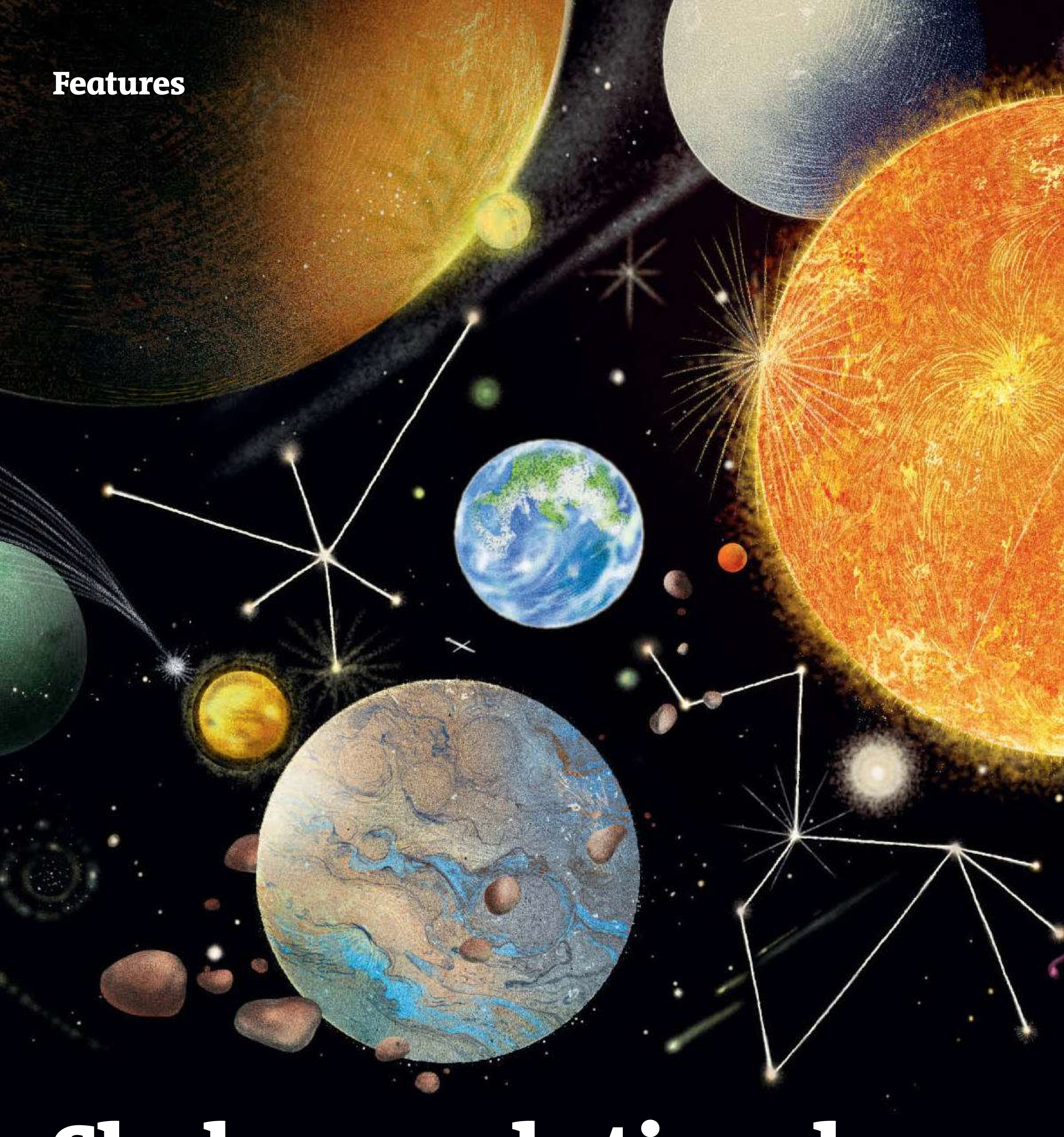
Our concepts of nature and wilderness sadly limit the solutions that we can imagine. Perhaps because of the bluntly extractive tendencies of their ancestors, it remains very difficult for many people with primarily European ancestry to wrap their minds around even the idea of a positive, mutually beneficial relationship with other species. Thus they can see only two conceptual options: destruction of nature by humans or separation of humans from nature. To save nature, we must exile ourselves from it – like latter-day Adams and Eves leaving Eden in shame after despoiling it.

We value "naturalness" so highly that in some places we are even willing to hurt and kill animals to protect it. When non-native animals are killed simply because they "don't belong" and not because they are clearly causing some measurable harm, we have decided that erasing the taint of the human is more important than the lives of animals – who, lest we forget, have no conception that they are in the "wrong" place.

To make good environmental decisions, we must stop focusing on trying to remove or undo human influence, on turning back time or freezing the non-human world in amber. We must instead acknowledge the extent to which we have influenced our current world and take some responsibility for its future trajectory. Given that we actively use at least half of Earth's land for our own ends and actively manage many of our protected areas, a gardening metaphor seems right. But our global garden is, and should be, rambunctious because we must always leave room for the autonomy of non-humans. We shouldn't seek to carefully control every plant and animal on the planet. We couldn't even if we wanted to.

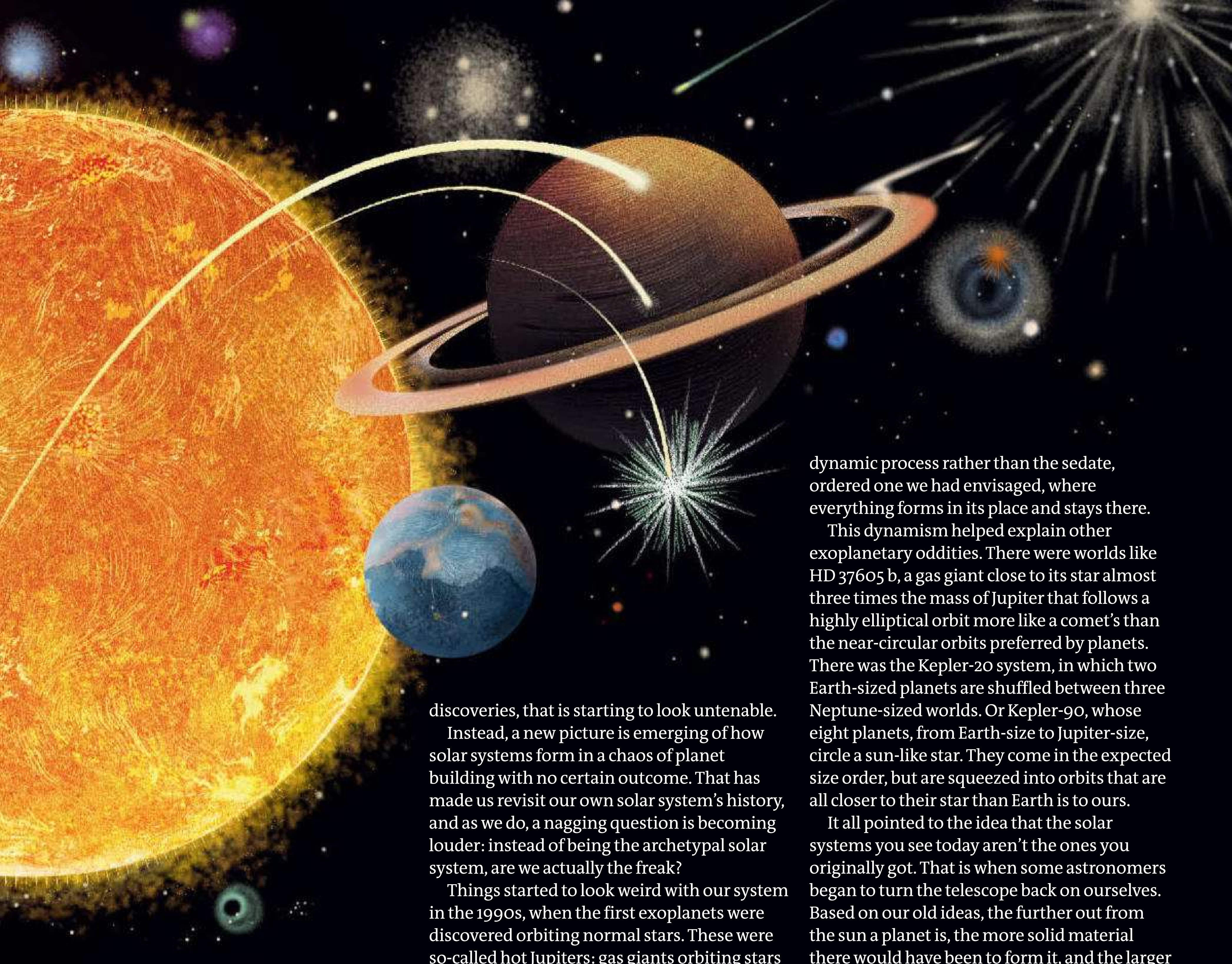
Rejecting the human/nature dichotomy doesn't mean condoning all human actions because, as animals, everything we do is "natural". Using "natural" as a substitute for "good" is the problem here, not the solution. Many human actions have been bad for us, bad for other species, bad all around. As a collective, we humans have clearly taken more than our fair share of space, water and other resources. But we don't fix that by exiling ourselves from the rest of Earth's species and building a wall between us. We fix that through repairing the systems by which we make our living, by learning – or re-learning – better, positive relationships with the species with which we share Earth. ■

Emma Marris is a writer based in Oregon. This is an edited extract from her new book, *Wild Souls*, published by Bloomsbury



Shaken and stirred

Discoveries in distant solar systems are disrupting ideas of why our own backyard looks like it does, says **Stuart Clark**



DUC LONG

ONCE upon a time, there was a solar system. In it lived four small rocky planets called Mercury, Venus, Earth and Mars. Four big gassy planets lived there too: Jupiter, Saturn, Uranus and Neptune. The four small planets lived close to the sun because it was very hot there, and everything else had been blasted away, leaving only rocks to make planets. But further out it was colder and there was lots of ice around, so the planets there grew into great big gassy giants.

This story wasn't originally written as a fairy tale. Until relatively recently, it was our solidly sourced story of how our solar system formed – in fact, how any solar system would form. But in the past decade or so, it has started to look, well, just a little contrived.

As we find large numbers of solar systems elsewhere in our galaxy, none of them look like ours. There are gas giant planets close to their parent stars, rocky planets larger than Earth, compact systems with rocky worlds slotted in between gas giants – anything goes. At first, we could dismiss these exotic exoplanets as oddballs, but after thousands more discoveries, that is starting to look untenable.

Instead, a new picture is emerging of how solar systems form in a chaos of planet building with no certain outcome. That has made us revisit our own solar system's history, and as we do, a nagging question is becoming louder: instead of being the archetypal solar system, are we actually the freak?

Things started to look weird with our system in the 1990s, when the first exoplanets were discovered orbiting normal stars. These were so-called hot Jupiters: gas giants orbiting stars so closely that a year lasts just a few days.

They were clearly the wrong worlds in the wrong place. Planets form from a dusty disc of gas around a young star. To make a gas giant, you first need a solid core of material several times Earth's mass to accrete, as a centre of gravity around which gas can accumulate. The torrent of radiation that a young star emits makes this impossible close to the star. "It will vaporise everything because it's so hot in that region," says Hannah Wakeford at the University of Bristol, UK. "Nobody, and I mean nobody, would say that these ultra-hot Jupiters formed close to their stars," says Stephen Mojzsis at the Collaborative for Research in Origins based in Boulder, Colorado. That leaves only one option: hot Jupiters must have formed elsewhere and moved closer. But how do you relocate a planet within a solar system?

Theorists soon came up with an answer. As a planet accumulates mass, its gravity can create density differences across the gas disc in which it forms, in turn altering the planet's angular momentum, causing it to spiral inwards or outwards. This turns planet formation into a dynamic process rather than the sedate, ordered one we had envisaged, where everything forms in its place and stays there.

This dynamism helped explain other exoplanetary oddities. There were worlds like HD 37605 b, a gas giant close to its star almost three times the mass of Jupiter that follows a highly elliptical orbit more like a comet's than the near-circular orbits preferred by planets. There was the Kepler-20 system, in which two Earth-sized planets are shuffled between three Neptune-sized worlds. Or Kepler-90, whose eight planets, from Earth-size to Jupiter-size, circle a sun-like star. They come in the expected size order, but are squeezed into orbits that are all closer to their star than Earth is to ours.

It all pointed to the idea that the solar systems you see today aren't the ones you originally got. That is when some astronomers began to turn the telescope back on ourselves. Based on our old ideas, the further out from the sun a planet is, the more solid material there would have been to form it, and the larger it should be. Beyond a certain point, however, the density of material begins to decline and planets should get smaller again.

This is where, in our solar system, you find two big problems: Uranus and Neptune. While it is true these two ice giants are considerably smaller than Jupiter and Saturn, the solar system's two mega-planets, they are still way too large for our models to explain how they formed where they are now.

Planetary migration provided a nifty solution in the form of the Nice model, named after the French city in which it was formulated in 2005. This suggested that all four giant planets were originally in a more compact configuration, but interacted gravitationally – first with the debris left over from their own formation and then with each other – until they spread into their current orbits. Besides explaining the size of Uranus and Neptune, the gravitational instability caused by the stirring giants would have swept through the early solar system, which would cause asteroids to rain down towards the sun, explaining the cratered surface of the moon. It could also account for how Jupiter acquired the Trojans, some 10,000 space rocks now trapped in two swarms in its orbit, and for the Kuiper belt, a ring of rocky material including Pluto beyond Neptune's orbit, which would have been scattered outwards during the migration.

The Nice model captured planetary scientists' imaginations, although one of its authors, Hal Levison at the Southwest Research Institute in Boulder, Colorado, sounds a note of caution. "If you'd have asked us whether we'd still be talking about it in 2021, we would have laughed because models come and go," he says. "It really did solve many problems, but it is just a model. That doesn't make it right."

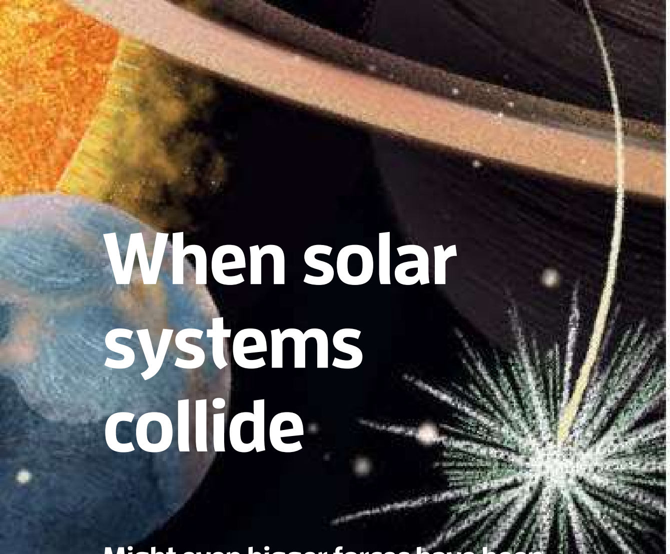
Nevertheless, it has become a framework within which astronomers now picture a dynamic early phase of our solar system's history – one that may have even involved influences from beyond it (see "When solar systems collide", left). "It is generally accepted that giant planet migration happened in our solar system," says Mojzsis.

Migration could also explain our solar system's most puzzling omission. It has small, rocky planets like Earth and gas giants like Neptune and larger, but nothing in between – if you discount reports of a mid-sized "planet nine" orbiting way out. Such a middling planet could be a large rocky one (a super-Earth), or a small gas giant (a mini-Neptune). Together,

> **"There is now a clear puzzle: where are the other solar systems like our own?"**

The moon's craters are evidence of violent changes in the early solar system

NASA



When solar systems collide

Might even bigger forces have been at work in the early solar system than those unleashed by planetary migrations? That is the conclusion reached by some astronomers studying the Kuiper belt, a ring of possibly more than 100,000 icy asteroids engirdling the solar system outside Neptune.

The Kuiper belt is itself thought to be the product of planetary migrations in the early solar system (see main story). But models of this process suggest that there should be a gradual decrease in Kuiper belt objects as we go outwards. Instead, astronomers see a precipitous drop off beyond about 50 times Earth's distance from the sun, a phenomenon known as the Kuiper cliff. Then there are Kuiper belt objects like Sedna that appear in highly elliptical, inclined orbits that defy conventional explanation.

Richard Parker at the University of Sheffield, UK, thinks he has an answer. He studies star clusters, jewel-box collections of stars that all form together from the same cloud of interstellar gas – a common origin that has consequences. "When stars are that tightly packed together, they know about each other," he says.

The basic idea is that gravitational interactions between stars mean they can throw each other's planets around, or disturb the disc of material from which those planets are forming. The very largest stars can even rain down a sleet of ultraviolet radiation on others, evaporating away the discs that the planets are feeding from, all of which would have profound effects on the orbits of the resulting planets.

According to Parker, our sun was born in a cluster and a close encounter with another star ripped away the more distant, smaller members of the Kuiper belt and disturbed the orbits of the larger ones. The interaction would also have resulted in the sun's ejection from its birth cluster – explaining why it now travels alone through space.

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these mid-range worlds make up over half the planets we know. "The fact that they're pretty much everywhere we look suggests they're easy to make," says Wakeford.

The absence could be explained if Jupiter migrated inwards at some point, disrupting the space in which a super-Earth would have formed. That could also explain why Mars is strangely small, just one-tenth of Earth's mass: Jupiter's movements would have cannibalised the material, stunting its formation.

Left unchecked, Jupiter would have pushed the inner planets – including Earth – to a fiery end inside the sun, while becoming a hot Jupiter itself. It didn't, because our solar system has not one mega-giant, but two – and Saturn saved the day. "It's about 80 per cent the size of Jupiter and that meant that Jupiter had a leash on it," says Wakeford. In this model, Saturn was migrating inwards too, but faster than Jupiter. As they got closer, they became locked into gravitational interactions that slowed and then reversed their migration, a scenario known as the "grand tack".

Fairy tales again? Perhaps. Mojzsis thinks that though the idea works dynamically, it is doomed geochemically. "Grand tack fails to explain the chemistry of the planets," he says. If you have Jupiter moving inwards, everything gets stirred up and mixed, but Earth and Mars have distinctly different compositions.

Whatever the details, however, we may now have hard evidence of some form of migration, if the analysis of a peculiar space rock that fell in India in 1870 is to be believed. Earlier this year, Fridolin Spitzer at the University of Münster in Germany and his colleagues showed that the Nedagolla meteorite contained a mix of ingredients from the inner and outer solar system, suggesting that something happened to blend these compositions.

But if planetary migration happens in our solar system as it does elsewhere, that leaves a puzzle: where are the other solar systems like our own? Back in the 1990s, astronomers were sure that after 15 years, we would find sister solar systems – above all, with Jupiter-sized planets where our Jupiter is. A quarter of a century on, nearly 5000 exoplanets are known. These are split between around 3600 planetary systems, with some 800 of those having multiple planets. Super-Earths, mini-Neptunes and hot Jupiters seem common, as are highly compact systems like Kepler-90. But precious few "Jupiter Jupiters" have been found.

NASA/USGS

New ideas of how our own solar system formed could explain why Mars is titchy

This could still be to do with how we find exoplanets. The problem is detection bias, according to Hugh Jones at the University of Hertfordshire, UK. Every detection method has an inbuilt sensitivity towards detecting certain types of worlds. For example, radial velocity surveys detect changing colours in a star's light when it is pulled by an orbiting planet's gravity, and are most sensitive to large planets very close to their stars. "Transit" surveys such as the Kepler space telescope, meanwhile, spy orbiting planets by the dimming of a star's light as they pass across its face, and have found most of the highly compact planetary systems.

Such biases make it hard to make definitive statements yet about what "normal" is. Solar systems like ours could be relatively common, but we just haven't seen them yet. The 15-year figure for finding one like ours was based on Jupiter taking 12 years to orbit the sun, giving time for a similar planet elsewhere to reveal itself. But "astronomers tend to be optimistic folks", says Richard Parker at the University of Sheffield, UK. "So when they tell you 15 years, what they probably mean is 30 years."

Thanks to the Nice model, we are also realising just how sensitive planet formation is to the details of the process. While the model was designed to reproduce the solar system, tweak it slightly and you get a whole different solar system. "Any one tiny change results in something completely different," says Wakeford. For example, Neptune could be flung right out of the system rather than shunted into a distant orbit, or Earth could be forced onto an elliptical orbit that would make habitability difficult.

Wakeford says we haven't quite yet grasped how these nuances can result in wildly different outcomes. Parker agrees. "Why wouldn't we expect planetary systems to be different when the processes that an individual star goes through [in its formation] can be completely different?" he says.

Thankfully, new information is on the way. The European Space Agency (ESA)'s Gaia mission and the European Southern Observatory's Very Large Telescope Interferometer both look for exoplanets in a different way, watching for how stars change position in response to the gravity of planets. ESA's 2026 Plato mission, a souped-up successor to Kepler, has been optimised to search for Earth-sized planets in the habitable zones of sun-like stars. "All these are things which help to erode our biases in the different parts of the discovery space," says Jones.

Meanwhile, we can hope for progress in the story of our own solar system's evolution. NASA's Lucy mission is currently en route to the Trojans. During a 12-year mission, it will encounter seven different asteroids in the two swarms, characterising them close-up for the first time. If the Trojans really are the result of planetary migration, their compositions could hold vital clues to the dynamics of the early solar system. "I think we've evolved to the point where we have many ideas, and don't really have enough data to distinguish one model from another," says Levison, who has switched from being a theorist to become principal investigator of the Lucy mission.

It remains to be seen whether any of these advances will bring clarity to our ideas of how solar systems look, and where ours fits in, or just more messiness. What is undoubtedly true is that at least one solar system brought forth a rocky planet where life could flourish. Whatever the nature of the story that led us here, that's a happy ending of sorts. ▮

Stuart Clark is a consultant for *New Scientist* and author of *Beneath the Night: How the stars have shaped the history of humankind*

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Science of gardening

How to feed your soil

Like your gut bacteria, the microorganisms in your soil need care, so give them a winter helping of organic matter, says **Clare Wilson**

Clare Wilson is a reporter at *New Scientist* and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

What you need

Manure or compost
A shovel

GAP PHOTOS

WINTER and early spring are a good time of year for gardeners to enrich their soil with organic matter such as manure and compost. Many of the plants have died back, leaving more room to dig the material into the soil or making it easier to just lay it on top with the "no-dig" technique that helps suppress weed growth too.

Uncultivated soils tend to contain 3 to 6 per cent organic matter, which accumulates from the natural cycle of plants dying and being broken down by microbes. Cultivated soils may be at the lower end of that range, because farmers or gardeners regularly remove plants that have died or been cropped.

Organic matter improves soil health in several ways. Most obviously, it releases nutrients crucial for plant growth as it is broken down. But it also helps to stop any nutrients from being washed away, because it binds the mineral particles of soil into larger aggregates.

Research published last year showed that soil with a greater amount of organic matter has a more porous structure, containing complex networks of air channels, less than the width of a human hair. It is unclear exactly how they form, but they seem to help oxygen circulate to plant roots and microbes, says Andy Neal at Rothamsted Research in the UK, who was involved in the study.

Neal and his team took X-rays of a soil particle to create 3D images of the air channels. They made a strangely hypnotic video of a journey zooming through a computer reconstruction of them (see it here: bit.ly/30zxvm8).

In the same way that it seems to be beneficial to feed your gut bacteria with a diverse diet, it also helps if you feed the microbes in your garden soil with a variety of organic matter, says Neal. "If you're composting, you're putting in a broad range of different types of plant material," he says.

You can judge if soil has enough organic matter by how it looks and feels – the ideal soil is dark in colour and crumbles easily in the hand when dry, according to the UK Royal Horticultural Society. But I generally add more once a year, to be on the safe side.

Depending on how big your garden is, it can be hard to get hold of enough organic matter. In a previous column, I described how you can make your own compost from kitchen and garden waste. This is a good way to reduce the amount of rubbish sent to landfill, but it doesn't yield large amounts of compost.

You can obviously buy compost or manure from garden centres, although this can be pricey. For my allotment, I order deliveries of horse manure from a local stables or collect it myself for free. It isn't smelly if it is already well rotted. Shovelling manure onto your soil is heavy work, but it leaves you with the rewarding feeling of having tucked your plants into bed for the winter. ▮

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Science of gardening appears every four weeks

Next week

Science of cooking

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"The trouble with the world is that the stupid are cocksure and the intelligent are full of doubt."
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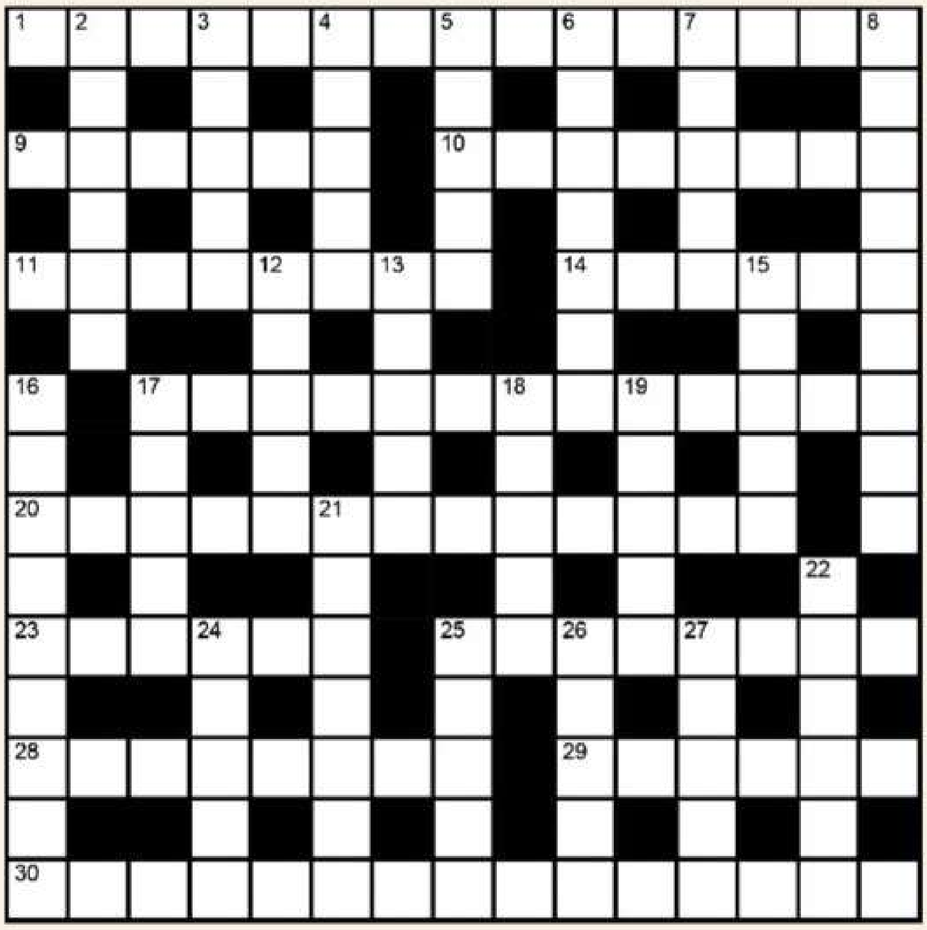
Quick crossword #97 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 This, for example (9,6)
9 Stationary (2,4)
10 Rock named after a county in Massachusetts, also known as nepheline monzogabbro (8)
11 Å (8)
14 Arid region (6)
17 Rainforest parrot of Indonesia (5,8)
20 Type of scholarly publication (8,5)
23 Structure of interrelated elements (6)
25 Shooting pain between the leg and lower back (8)
28 Cogitating (8)
29 Slips, gaffes, boobs (6)
30 Fleshy growth in the lower bowel (10,5)

DOWN

2 Light-sensitive region of the eye (6)
3 Embryonic plants (5)
4 H_2O (5)
5 Mucus discharged from the eyes (5)
6 Academic with a PhD (7)
7 Third of three axes in a Cartesian coordinate system (1-4)
8 Conductor in contact with a non-metallic part of a circuit (9)
12 Boreal forest (5)
13 ___ acid, $C_{18}H_{34}O_2$ (5)
15 Computer key (5)
16 Adapted to live harmfully within or on another organism (9)
17 Flying insect in the suborder Apocrita (5)
18 Middle Eastern oil consortium (initialism) (5)
19 K (5)
21 Type of firearm cartridge (7)
22 Illness caused by vitamin C deficiency (6)
24 T in the NATO Phonetic Alphabet (5)
25 Vision (5)
26 Perfect (5)
27 Trunk of the human body (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #130

1 What name is given to the boundary where the solar wind is stopped by the interstellar medium?

2 *Bradypus* and *Choleopus* are the two extant genera of which mammals?

3 What are flowering plants also known as?

4 In what year did Patrick Blackett show that radioactivity could cause one element to transmute into another?

5 A prime number that is 1 less than a power of 2 is known as what?

Answers on page 55

Puzzle

set by Kyle Evans

#142 Simultaneous pleasure

😀😀😀 + 🤯🤯 = 22
😀😀 + 🤯🤯🤯 = 23

During lockdowns, I researched viral internet maths sensations. Several of them are what a teenager might recognise as simultaneous equations. In the emoji example above, smiley faces = 4 and blown minds = 5. Simultaneous equations without emojis are less likely to go viral, but can be more fun. Here are two of my favourites.

1. A pen and a pencil cost £1 together. The pen costs 90p more than the pencil. How much do they each cost?

2. There are some cows and some chickens in a field. I can see 40 eyes and 64 legs. How many are there of each animal?

Solutions next week

Kyle Evans's book, *Maths Tricks to Blow Your Mind*, is available now

Time to panic

We are often told that "now is not the time to panic" when a crisis is looming or happening. When is the right time to panic?

Garry Trethewey
Cherryville, South Australia
Panic causes poor decision-making and irrational actions, and so is dysfunctional.

On the other hand, it might be good to panic when one simple and obvious behaviour is needed, such as running away from a tiger in spite of a broken leg.

Hillary Shaw
Newport, Shropshire, UK
Panic may be beneficial when there is no known survival option. If death is 100 per cent certain, then doing something, even running round in circles, must be better than doing nothing. You may even find a survival option you overlooked before, and then you can't be worse off than by not panicking.

> "Is there ever a good time to lose the ability to think rationally, to be frozen with fear and lose self-control? Probably not"

Clive Tiney
Haxby, York, UK
The question is really "is there ever a good time to lose the ability to think rationally, to be frozen with fear and lose self-control?"

The answer is probably not. The one exception might be to confuse something hunting us. Running away in panic may allow us to move faster without thought for the consequences of abrasions or hidden dangers.

Rudi Pertot
Diamond Beach, New South Wales, Australia
This is not an answer to the question as such, but it did bring to mind the saying, "If you are cool, calm and collected, while all about you are panicking and losing their heads, then you obviously don't understand the problem".

Andrew Hunt
London, UK
The right time to panic is just before everyone else does. In other words, to anticipate the crisis and take steps to ensure that, at worst, you won't be negatively affected, and at best, that you can capitalise on the opportunities that the crisis may present.

Brian Battuello
Arlington, Massachusetts, US
In the immortal words of Inspector Closeau in *The Return of the Pink Panther*: "There is a time and a place for everything... and this is it!"

From a dog's perspective, are their owners their friend or more like a prison guard?

RICH VINTAGE PHOTOGRAPHY/GETTY IMAGES

This week's new questions

Warming waves **As waves break and dissipate their power, does this energy warm the water?** ***John*** **Courcier**, *Coffs Harbour, Country of the Gumbaynggirr People, Australia*

Best friends? **Are pet dogs just suffering from Stockholm syndrome, or do they genuinely enjoy our company?** ***Bob Baker***, *Hampshire, UK*

On the boil

When cooking, what difference does it make if the water is simmering or boiling vigorously, given that water boils at 100 degrees?

Eric Kvaalen
Les Essarts-le-Roi, France
It doesn't matter, unless you are trying to evaporate a portion of the water. A rapid boil is a big waste of energy. In fact, it would be best to maintain the pot at 100°C without any simmering. There are temperature probes that can be put in a pot and which control the heating, allowing energy expenditure to be reduced.

It is fortuitous that water boils at a temperature that allows food to be cooked. If it boiled at a lower temperature, we would have difficulty cooking food, and if it boiled at a higher one, food would easily get overcooked.

Tim Lewis
Narberth, Pembrokeshire, UK
I have never been able to persuade my partner that it takes just as long to cook vegetables whether they are boiling furiously or simmering. More energy is used and more steam is produced when boiling though. Cooking times by boiling can be shortened only by using a pressure cooker.

Greg Harris
Abu Dhabi, United Arab Emirates
For a chef, the difference between boiling and simmering is crucial. The strength of the boil affects the rate of reduction, important for producing water-based sauces, and is critical for avoiding the scorching of food at the bottom of the pot.

The 100°C temperature limit cannot be exceeded under sea-level conditions, but a pressure cooker can be used to raise the boiling point. However, the cooking of everything from red sauce to pastries is complicated by altitude. My occasionally Colorado-based parents have often softened the delivery of a potentially below par meal with a caveat about the unreliability of our old recipies at 2172 metres up!

Martin Pitt
Leeds, UK
Vigorously boiling water heats food faster than static water does at the same temperature for the same reason that wind cools faster than static air at the same temperature.

In both cases, there is a layer of fluid/gas on the surface of the object that provides insulation. Movement reduces or strips off this layer. Boiling provides this motion, and the more vigorous, the greater the effect.

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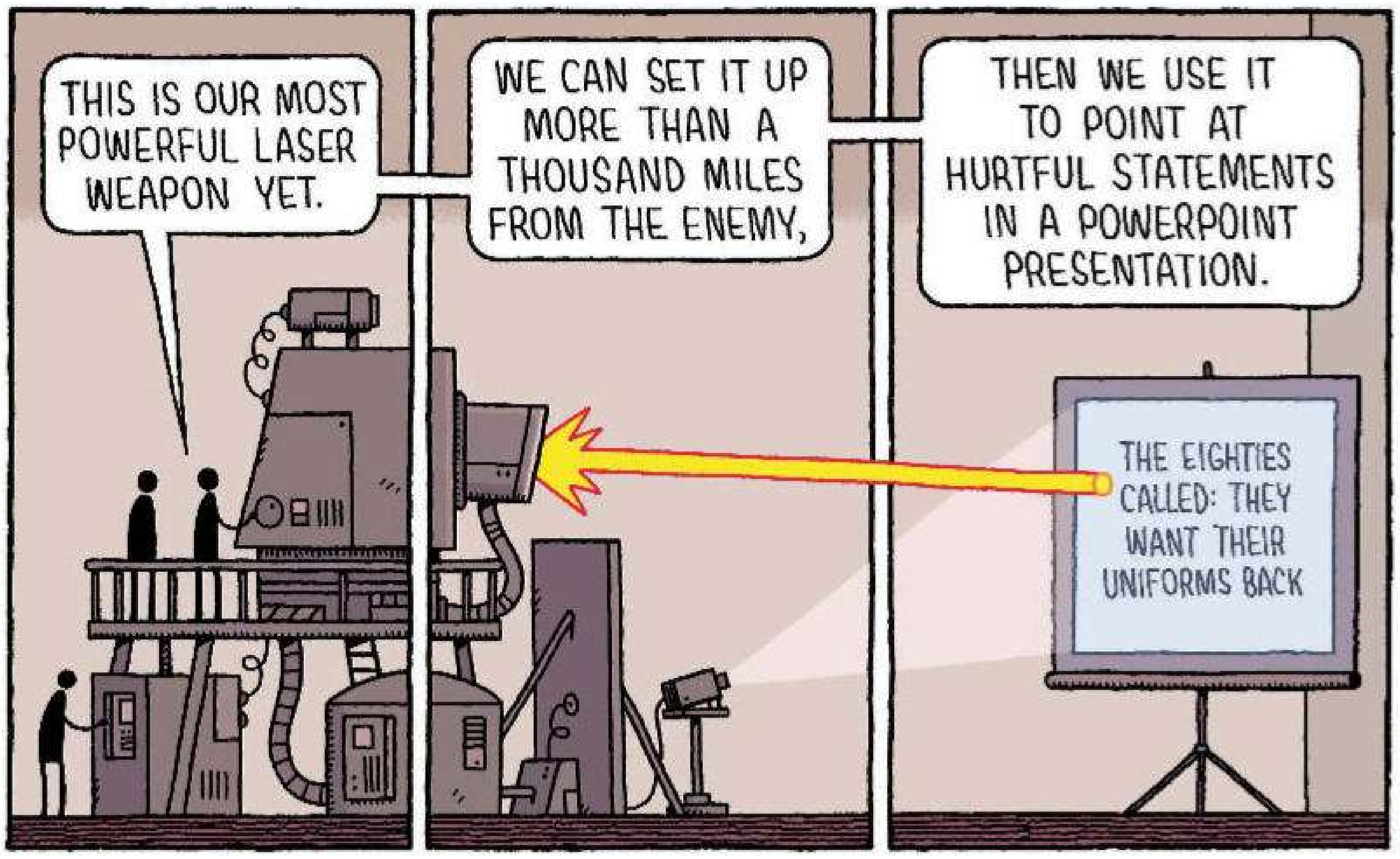
THIS IS OUR MOST POWERFUL LASER WEAPON YET.
WE CAN SET IT UP MORE THAN A THOUSAND MILES FROM THE ENEMY,
THEN WE USE IT TO POINT AT HURTFUL STATEMENTS IN A POWERPOINT PRESENTATION.
THE EIGHTIES CALLED: THEY WANT THEIR UNIFORMS BACK

David Muir
Edinburgh, UK
If you put potatoes into boiling or simmering water, both at 100°C, they will cook equally quickly as heat is conducted directly from the water to the vegetable. Any heat over that required to reach 100°C converts liquid water to water vapour.

This heat is then lost to the room when the vapour condenses in the air to form steam or to produce condensation on cold surfaces, like windows.

It is a different kettle of fish if you are steaming vegetables that aren't in direct contact with the boiling water. As water vapour condenses on the vegetables, they are cooked by the latent heat of evaporation when the vapour condenses on the vegetable.

In this case, the faster you boil the water, the more vapour that is produced and the greater the amount of condensation on the vegetables, cooking them faster. This also explains why a scald due to steam can be more severe than scalding from boiling water.

> "A rapid boil is a big waste of energy. It would be better to maintain the pot at 100°C without any simmering at all"

Guy Cox
Sydney, Australia
When water is actively boiling rather than simmering, we are putting more heat into the pan than is required to maintain its temperature.

This means that when we put food items in, they will reach cooking temperature more rapidly, because the excess heat can transfer to the food. This stops food getting soggy and reduces cooking time a bit.

However, once the food reaches 100°C, there will be no further impact on its cooking time, so it is usually better to reduce the heat so the water simmers. The exception is if the turbulence of a rapid boil would be useful to prevent items sticking together.

Changing tune

Will composers run out of new combinations of musical notes to create original melodies? Or are there infinite combinations? (cont.)

Jeff Dickens
Strachan, Aberdeenshire, UK
Previous responses (13 November) to this question contained some laudable arithmetic, but there was no mention of composer John Cage's simple demonstration that the answer must be yes: there exists an infinity of combinations.

Cage provided us with his piece *4′33″* (4 minutes and 33 seconds), a work in three movements, for any instrument or combination of instruments, in which the ensemble plays not a single note. Instead, we are invited to attend to the space thus created.

By logical extension, there must exist an infinity of other compositions, because any other work could be considered as *4′33″* with one of an infinity of different durations and an infinity of added sounds. ▮

Answers

Quick quiz #130
Answers

1 The heliopause

2 Sloths

3 Angiosperms

4 1925

5 A Mersenne prime

Cryptic crossword #71 *Answers*

ACROSS 1 Aestival, **5** Data, **9** Uglis, **10** Tornado, **11** Toddles, **12** Numb, **14** Racing, **16** Douche, **19** Bait, **21** Latakia, **24** Ash tree, **25** Igloo, **26** Best, **27** Necrosis

DOWN 1 Abutters, **2** Salad, **3** Insulin, **4** Attest, **6** Anaemic, **7** Agog, **8** Iron, **13** Decapods, **15** Cha-chas, **17** Outlier*, **18** Allele, **20** Torc, **22** Kilos, **23** Jamb

The hidden names in the grid are Banting (row 2), J. Collip (row 10), Macleod (row 12) and Best (row 13), who all contributed to the discovery of insulin.

* Apologies. The clue for 17 Down should have read: Banker ultimately upholding public falsehood? That's unusual (7)

#141 Sam's speed
Solution

10 kilometres at 30 kilometres per hour takes 20 minutes, so Sam has 10 minutes left to drive the remaining 10 kilometres. This means he now needs to maintain a speed of 60 km/h.

Load of old...

The stereotype of scientists as unfeeling automatons is lazy and, in Feedback's experience, entirely inexplicable. On the contrary, the passions the pursuit of knowledge bring to the boil often froth over in raw, all-too-real emotion.

We feel this with a 2020 paper in the journal *ACS Nano* from Martin Pumera at the Center for Advanced Functional Nanorobots at the University of Chemistry and Technology in Prague that our science fiction columnist Sally Adee sends us, entitled "Will any crap we put into graphene increase its electrocatalytic effect?"

Ah graphene, that two-dimensional carbon wonder-repository of hopes, dreams and the UK government's entire industrial strategy. As far as Feedback can discern, the bone of contention this paper is tearing hunks of raw meat off is whether you can boost energy-producing chemical reactions within hydrogen fuel cells and the like by adding a pinch of other chemical elements to their graphene-surfaced electrodes.

"To make our point of the meaninglessness of efforts to co-dope graphene with various elements experimentally, we evaluate in this work if guano-doped graphene poses any advantages over nonguano-doped graphene," the researchers write, with forthrightness of both word and intent. Having basted graphene in bird poo, they conclude that it does.

Feedback is impressed, although not entirely surprised: after all, back in the day nations went to war over guano for its nitrogen, phosphorus and sulphur content, prized for making fertiliser and gunpowder. Now just add it to the list of clean energy's potential dirty secrets (13 November, p 38). Unless of course the whole thing's a pile of old crap. We say this entirely without feeling.

Twisteddoodles *for New Scientist*

TOAST LANDS BUTTER SIDE DOWN
BUT CATS ALWAYS LAND ON THEIR FEET
BUT WHAT WOULD HAPPEN IF YOU COMBINED THE TWO?
MAY WE PRESENT OUR NEW INVENTION.
THE UNFEASIBLY LARGE NON-STOP MIAOWING BUT FOR SOME REASON MAKING YOU HUNGRY HOVER BOARD.
@twisteddoodles

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King bee

Joyously, Lars Chittka, professor of sensory and behavioural ecology at Queen Mary University of London, takes to Twitter with a picture of a subscription communication from *chez nous*. "For years, the New Scientist addressed me as Queen L Chittka – probably an AI conflation of my name and address," he writes. "Now some automatism has added 'Her Royal Highness'."

We ascribe this not to automatism, Lars, but the ghost in our machine's appreciation of your cutting-edge research on the sensory and navigational capabilities of bees, a world in which there is only one description for the top, errm... dog. We think it's rather sweet, but if you want us to try to unjam said machine, do let us know.

Horny problem

Many thanks to most of Canada, and also, pleasingly, John Burman of Port Macquarie, Australia, who write in pointing out the only news of real significance last week: Air Canada's announcement that, in response to the devastating floods that cut key supply links to southern British Columbia, it would be temporarily adding goods capacity into Vancouver airport "equivalent in weight to approximately 860 adult moose".

We add this to our towering pile of "Culturally relevant measurement units (Canada)", while idly wondering what 43 score moose translate to volumetrically. This raises the interesting problem of optimal moose tessellation, which may require more mathematical firepower than our speculative doodles of interlocking antlers. The related question of how many adult male African elephants the moose convert to is of course only relevant if they are flying in a jumbo jet.

Uncertain times

Feedback understands that the nature of quantum reality and the location of the boundary between its fuzzy realm and our solid, classical world are active areas of research, if only for a certain, small value of "understands". Seeking further enlightenment, we have for many years been an eager student of quantum overspill effects into the classical realm.

"Please enter thru both doors," a board with arrows pointing right and left instructs Jonathan Stoppi in the Mary Winspear Centre in Sidney, British Columbia. "Please have your proof of vaccination and photo ID ready to present."

This second part in particular rather puzzles us. Even supposing an individual's quantum trajectory can be recombined behind the doors, what does a positive proof of vaccination there tell us about vaccination status before they pass through the doors? Possibly for the purposes of the Mary Winspear Centre this doesn't much matter, but we think we should be told.

Viro-robo-cop

More signs of the times, as a paper in *PLoS One* details a robot than can enforce social distancing. Using lidar and a depth camera, Soditbot – as no one has called it, yet – can remotely detect groups of people breaching a safe 2-metre distance in crowded environments and glide in, displaying a stern message on a laser display screen.

This is admittedly not an entirely new idea – Feedback recalls the robodog that patrolled a Singapore park broadcasting social distancing messages via a loudhailer last year, and similar, less cute robot enforcers in the island city state. Nevertheless, we agree with a colleague who suggests that if this is really to work, the robot needs to be equipped with a water pistol or Nerf gun. We just hope Soditbot is regularly wiped, so as not to become a vector itself. ▮

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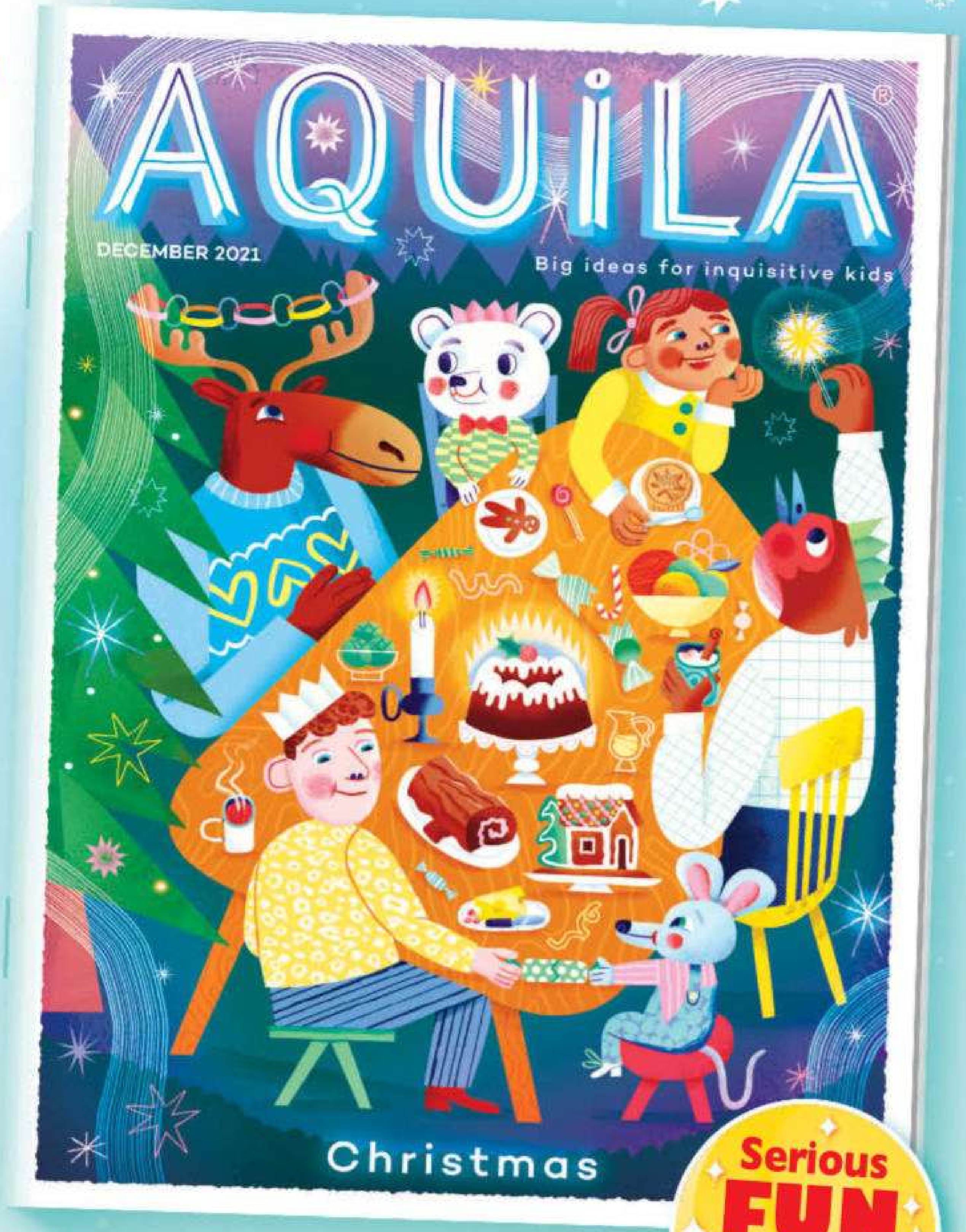

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